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Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1988

M. Stocker, N. Bourne, B. Riddell,
J. Schweigert and A. Tyler, [Editors]

Department of Fisheries and Oceans
Biological Sciences Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

June 1989

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2020

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact parait au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

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Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences No. 2020

June 1989

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1988

by

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J. Schweigert and A. Tyler [Editors]

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Biological Sciences Branch

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90-00502/

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Cat. No. Fs 97-4/2020E ISSN 0706-6473

Correct citation for this publication:

Stocker, M., N. Bourne, B. Riddell, J. Schweigert and A. Tyler [Editors]. 1989. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1988. Can. MS Rep. Fish. Aquat. Sci. 2020: 231 p.

Chairman's Report for 1988

This is the third Annual Report of PSARC, summarizing the fourth year of operation of the committee providing biological advice on the status of Pacific fisheries resources. In 1988 PSARC established again a complete annual meeting schedule, and the Salmon Subcommittee held its first major annual meeting. This allowed PSARC to provide biological advice in a timeframe that is consistent with the regional consultative and decision making process prior to scheduled fisheries.

In 1988, 57 Working Papers were prepared, providing the basis for the biological advice for Pacific fisheries resources. The resulting five Advisory Documents are contained in this report.

The Salmon Subcommittee Report resulting from the first major annual meeting of the Salmon Subcommittee was reviewed by the Steering Committee on April 19-20, 1988. The resulting Advisory Document was submitted to the regional Fisheries Resource Management Executive Committee (FRMEC) on May 23, 1988. The Steering Committee emphasized that immediate action should be taken to acquire a minimum set of data annually to improve stock assessments for actively managed salmon stocks.

Steering Committee review of the 1988 PSARC Shellfish, Herring, and Groundfish Subcommittee Reports took place on September 16, 1988. PSARC presented the respective Advisory Documents to FRMEC on September 26, 1988. The approved biological advice was used by Fisheries Managers to prepare fishing plans for the region.

The Salmon Subcommittee Report on technical issues pertaining to the 1988 Pacific Salmon Commission negotiations was reviewed by the Steering Committee on November 25, 1988. The resulting Advisory Document was submitted to FRMEC on December 6, 1988.

My term of office as Chairman of PSARC expired at the end of 1988. The FRMEC has appointed Ms. S. Farlinger from the Fisheries Branch as the chairperson for 1989-90. There were some changes in the composition of the Steering Committee in 1988. In April C. McKinnon replaced D. Radford as the representative of the Program Planning and Economics Branch. In September, Dr. D. McKone became the Headquarter's representative replacing Dr. B. Ayles. D. Radford took over the chair of the Data Systems Subcommittee from L. Lapi whose term of office has been completed. PSARC extends its thanks to these outgoing members for their invaluable contributions.

This document is the result of a process. It presents the efforts of the stock assessment community in the Pacific Region. The principal contributors are those authors listed in the PSARC Working Paper Index for 1988. Numerous other members of DFO staff played key roles in producing this effort. I want to take the opportunity to thank all those who contributed so much to make 1988 another successful year of operation of PSARC. I am particularly grateful to my colleagues on the Steering Committee, and the members of the FRMEC for their continued support. The efficient and helpful secretarial help provided by Placements Vancouver Island is also much appreciated.

M. Stocker
Chairman

Rapport du président - 1988

Vous trouverez dans ce troisième rapport annuel du Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) un résumé de la quatrième année d'activité du comité chargé de fournir des conseils de nature biologique sur les ressources halieutiques du Pacifique. En 1988, le CEESP a de nouveau établi le calendrier de la réunion annuelle et le Sous-comité sur le saumon a tenu sa première grand réunion annuelle. Ceci a donné au CEESP l'occasion de faire ses recommandations en temps opportun dans le cadre du processus régional de consultation et de prise de décision, avant le début des pêches.

En 1988, nous avons produit 57 documents de travail. Ces derniers ont servi de documents de consultation pour fournir des conseils sur les ressources halieutique de Pacifique et pour rédiger les cinq documents de consultation qui sont contenus dans ce rapport.

Les 19 et 20 avril 1988, le Comité directeur a étudié le compte rendu préparé par le Sous-comité sur le saumon à la suite de sa première grande réunion annuelle. Le document de consultation produit à la suite de cette étude a été présenté au Comité exécutif régional sur la gestion des ressources halieutiques (CEGRH) le 23 mai 1988. Dans son compte rendu, le Comité directeur a souligné qu'il faut immédiatement prendre des mesures pour recueillir un minimum de données de base annuellement afin d'améliorer l'évaluation des stocks de saumon dans le cadre de la gestion du saumon.

Le 16 septembre 1988, le Comité directeur a étudié les rapports de 1988 du CEESP sur les mollusques et les crustacés, le hareng et le poisson de fond. Le CEESP a présenté les différents documents de consultation au CEGRH le 26 septembre 1988. Les gestionnaires des pêcheries se sont fondés sur les conseils biologiques approuvés pour préparer leurs plans de pêche régionaux.

Le 25 novembre 1988, le Comité directeur étudiait le rapport du Sous-comité sur le saumon concernant les questions techniques liées aux négociations de la Commission du saumon du Pacifique pour 1988. Le document consultatif produit à la suite de cette étude a été présenté au CEGRH le 6 décembre 1988.

Mon mandat de président du CEESP a expiré à la fin de 1988. M^{me} S. Farlinger, de la Direction des pêches, a été nommée présidente du CEGRH pour 1989-1990. En 1988, il y a eu des changements au sein du Comité directeur. En avril, C. McKinnon a remplacé D. Radford au poste de représentant de la direction de l,Économique et de la planification des programmes. En septembre, le D^{r} D. McKone est devenu représentant de l'Administration centrale, en remplacement du D^{r}. B. Ayles. D. Radford a assumé le poste de président du Sous-comité des systèmes de données à la fin du mandat de L. Lapi. Le CEESP aimerait remercier les membres du Comité pour leur excellent travail.

Ce document présente le résultat du travail des groupes qui évaluent les stocks dans la région du Pacifique. Les principaux collaborateurs sont les auteurs énumérés dans l'index de Document de travail de 1988. De nombreux employés du MPO ont également tenu un rôle prépondérant. Je désire profiter de l'occasion pour remercier tous ceux qui ont contribué au succès des activités du CEESP. Je remercie tout spécialement mes collègues du Comité directeur et les membres du CEGRH de leur appui indéfectible. Le soutien administratif fourni par Placements Vancouver Island a également été très apprécié.

Le président,

M. Stocker

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Section I

Report on Committee Activities

Terms of Reference
Pacific Stock Assessment Review Committee
(PSARC)

Organizational Structure

PSARC is a Departmental Committee that reviews biological advice on the status and management of Pacific fisheries resources. The Committee reviews methodologies and criteria employed in the stock assessment process, and formulates and evaluates methodologies employed to establish management plans and to assess local fisheries. In terms of a broad definition, PSARC encompasses the stock assessment community of D.F.O. in the Pacific Region responsible for providing biological advice to senior management in the Region. PSARC is controlled, organized and administered by a steering committee, which reports to the Resource Management Executive Committee - Pacific. The Chairman reports to the Director-General, and will serve for a 2-year term.

The technical work of the organization is performed by subcommittees, organized on a species or subject basis. Subcommittees are established and disbanded by decision of the Steering Committee and report to it.

Terms of Reference

1. PSARC is responsible for (1) reviewing and evaluating biological advice and technical advice on the status and management of Pacific fisheries resources, and (2) evaluating estimation and assessment methods and criteria used in the Region.

2. PSARC will formulate and evaluate methodologies for assessment and decision making for Pacific fisheries, and will advise the Resource Management Executive Committee of sound and appropriate methods for fisheries management in the Region.

3. PSARC shall provide scientific and technical advice to the Resource Management Executive Committee - Pacific on matters relating to fishing statistics, sampling of catches, information needs for stock assessments, and coordination of resource assessment and related projects between Branches in the Pacific Region.

4. PSARC will identify resource assessment-related research priorities, and by so doing, will provide input into the regional planning process.

5. PSARC will endeavour to ensure liaison with other regional committees. Such liaison will include mutual referral and joint meetings with other fora as required so as to ensure consistency of biological advice with long-term Pacific fisheries management objectives.

The Steering Committee

Composition

The Steering Committee includes 16 members as follows:

1 Chairman
1 F.R.B Section Head from Salmon, or delegate
3 F.R.B Section Heads from Marine Fish (Groundfish, Herring, and Shellfish), or delegate
5 Subcommittee Chairmen
1 Past-Chairman
1 Head, Biological Services, Fisheries Branch
1 Chief, Resource Allocation and Industry Liaison, Fisheries Branch
1 Delegate from Regional Planning and Economics Branch
1 Delegate from S.E.P.
1 Delegate from Ottawa

The immediate past Chairman and appointed members will serve on the Steering Committee for a 2-year term.

Responsibility of the Committee

The Steering Committee is established to provide a framework for reviewing Subcommittee biological advice that goes forward to senior management and to take the responsibility for advice from individuals of the stock assessment community and place it in the hands of the corporate structure.

The Steering Committee reviews the Subcommittee reports to ensure all relevant information has been evaluated and thoroughly analyzed, and to formulate appropriate biological advice on management questions in the broader context of Departmental policy. It is also vested with the responsibility for identifying weak areas in the scientific database and methodology used by the Subcommittee to reach conclusions and to recommend corrective actions. Items may be referred back to the Subcommittees for further consideration or be accepted as a basis for advising senior management in the form of Advisory Documents or memoranda.

PSARC has the responsibility of generating and providing biological advice to the Resource Management Executive Committee.

Responsibility of Members

It is the responsibility of members of the Steering Committee to attend all regular meetings if possible regardless of whether items being discussed are in their area of expertise in order to provide a broad-based evaluation of biological advice generated from PSARC. If the members cannot attend meetings they should appoint an alternate for meetings at which they are unable to be present.

The definition of a quorum will be left to the discretion of the Chairman.

Members are required to send copies of all correspondence and reports pertaining to PSARC business to the Chairman so up-to-date files can be maintained.

Members are required to forward editorial modifications to Proceedings to the Committee Chairman; they will not be discussed at the meeting. Corrections of a substantive nature will, however, continue to be brought to the Committee.

Each Steering Committee member, when asked for a scientific opinion on matters contained in approved Committee reports, should give the collective judgement of the Committee even if it differs from his/her personal opinion.

Schedule of Meetings

The Steering Committee has at least 3 regular annual meetings. Generally speaking, these meetings occur in the fall for reviewing subcommittee biological advice, and in early spring for planning the year's activities. Other meetings may be called as required at the discretion of the Chairman, or by request of members of the Steering Committee.

Communication with Line Management

Advisory Documents are to be submitted to the Resource Management Executive Committee.

After Advisory Documents are approved for release by the Resource Management Executive Committee, they are distributed to the management working groups, the ADM - Pacific and Freshwater, ADM Science, and other regional staff interested in receiving a copy. Notification to the Chairman of PSARC for approval of release of all Advisory Documents is coordinated through the office of the Director-General.

A listing of PSARC documentation will be forwarded to Division Chiefs and Section Heads with the request that they indicate what information they would like to receive on a routine basis. This includes PSARC Proceedings and Subcommittee Reports. This is intended to keep key managerial staff informed of PSARC activities. They are expected to respect the citation guidelines of documents so received.

Subcommittee Chairmen can communicate directly with scientific staff if this communication is restricted to matters that are for information purposes and do not have program repercussions. Items relating to program implementation and requests for assistance are to be referred to Directors for approval prior to direct communication with the departmental stock assessment community.

Subcommittees

1. The following five Subcommittees deal with the specialized areas indicated:

   PSARC Salmon Subcommittee
   PSARC Herring Subcommittee
   PSARC Groundfish Subcommittee
   PSARC Shellfish Subcommittee
   PSARC Stock Assessment Data System Subcommittee

2. Participating branches shall nominate Chairmen for each Subcommittee in whose work it is involved. Chairmen are responsible for communicating proposed agendas to members, participants, and reviewers and coordinating their preparations for and participation at Subcommittee meetings. Chairmanship should rotate between branches every 2 years.

3. Participation at Subcommittee meetings shall include departmental stock assessment staff as appropriate, and at the discretion of the Subcommittee Chairman, D.F.O. scientists from other Regions, and non-D.F.O.scientists, for discussion of specific topics.

4. PSARC will appoint internal reviewers from the stock assessment community to participate in Subcommittee meetings in other than their own discipline. The Steering Committee will select and approve external reviewers nominated by Subcommittee Chairmen.

PSARC Salmon Subcommittee

The PSARC Salmon Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all salmon stocks presently exploited, or with potential to be exploited, by:

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of salmon stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on salmon management as may be required by PSARC;
- maintaining a written record of the Proceedings of the Subcommittee documenting the recommendations of the Subcommittee, the scientific basis of such recommendations, and resultant management actions;
- critically reviewing externally published reports of scientific research, and commenting on matters relevant to the Subcommittee's mandate;
- reviewing stock assessment-related research programs on salmon, and commenting on their relevance and effectiveness in relation to management of these resources;
- providing a forum for coordination of stock assessment related research programs on salmon;
- reviewing research requirements for salmon resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Herring Subcommittee

The PSARC Herring Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all herring stocks presently exploited, or with potential to be exploited, by:

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of herring stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on herring management as may be required by PSARC;
- maintaining a written record of the proceedings of the Subcommittee documenting the recommendations of the Subcommittee, the scientific basis of such recommendations, and resultant management actions;
- critically reviewing externally published reports of scientific research, and commenting on matters relevant to the Subcommittee's mandate;
- reviewing stock assessment related research programs on herring, and commenting on their relevance and effectiveness in relation to management of these resources;
- providing a forum for coordination of stock assessment-related research programs on herring;
- reviewing research requirements for herring resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Groundfish Subcommittee

The PSARC Groundfish Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all groundfish stocks presently exploited, or with potential to be exploited, by:

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of groundfish stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on groundfish management as may be required by PSARC;
- maintaining a written record of the proceedings of the Subcommittee documenting the recommendations of the Subcommittee, the scientific basis of such recommendations, and resultant management actions;
- critically reviewing externally published reports of scientific research, and commenting on matters relevant to the Subcommittee's mandate;
- reviewing stock assessment related research programs on groundfish and commenting on their relevance and effectiveness in relation to management of these resources;
- providing a forum for coordination of stock assessment related research programs on groundfish;
- reviewing research requirements for groundfish resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Shellfish Subcommittee

The PSARC Shellfish Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all shellfish stocks presently exploited, or with potential to be exploited, by:

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of shellfish stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on shellfish management as may be required by PSARC;
- maintaining a written record of the proceedings of the Subcommittee documenting the recommendations of the Subcommittee, the scientific basis of such recommendations, and resultant management actions;
- critically reviewing externally published reports of scientific research, and commenting on matters relevant to the Subcommittee's mandate;
- reviewing stock assessment related research programs on shellfish and commenting on their relevance and effectiveness in relation to management of these resources;
- providing a forum for coordination of stock assessment-related research programs on shellfish;
- reviewing research requirements for shellfish resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Stock Assessment Data System Subcommittee

It is the responsibility of the Stock Assessment Data System Subcommittee to provide the scientific and technical basis for PSARC advice on catch statistics, catch sampling, and biological surveys to D.F.O. Pacific, by:

- defining the stock assessment information needs of the stock assessment community and evaluating the adequacy of information provided to meet these needs;
- reviewing Regional data management priorities, and recommending work priorities to the Computer Services Division, and review policies, procedures, and schedules to ensure they meet Regional priorities and integrate with PSARC;
- developing an integrated stock assessment data system, and reviewing stock assessment-related E.D.P. work plans and assign priorities; and
- maintaining a written record of the Proceedings of the Subcommittee documenting the conclusions of the Subcommittee, the scientific basis for such conclusions, and of actions taken by other Regional groups based on the Subcommittee's conclusions.

PSARC STEERING COMMITTEE

Dr. M. Stocker, Chairman
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and Chairman - PSARC Salmon Subcommittee
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Mr. J. Schweigert, Chairman
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LIST OF MEETINGS, 1988

1. PSARC Salmon Subcommittee Meeting - March 14-17, 1988 - Pacific Biological Station, Nanaimo, B.C.

2. PSARC Steering Committee Meeting - April 19-20, 1988 - 555 West Hastings, Vancouver, B.C.

3. PSARC Workshop on Stock Monitoring and Assessment Requirements for Coho Salmon in British Columbia - June 7-9, 1988 - Royal Oak Inn, Victoria, B.C.

4. PSARC Shellfish Subcommittee Meeting - August 30-31, 1988 - Dunsmuir Lodge, Sidney, B.C.

5. PSARC Groundfish Subcommittee Meeting - September 1-2, 1988 - Pacific Biological Station, Nanaimo, B.C.

6. PSARC Herring Subcommittee Meeting - September 7-8, 1988 - Richmond Inn Island Hall, Richmond, B.C.

7. PSARC Steering Committee Meeting - September 16, 1988 - Coast Bastion Inn, Nanaimo, B.C.

8. PSARC Stock Assessment Data System Subcommittee - November 10, 1988 - 555 West Hastings, Vancouver, B.C.

9. PSARC Salmon Subcommittee Meeting - November 14 - 15, 1988 - 555 West Hastings, Vancouver, B.C.

10. PSARC Steering Committee Meeting - November 25, 1988 - Coast Bastion Inn, Nanaimo, B.C.

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1. Herring		
H88-1	Stock assessments for British Columbia herring in 1988 and forecasts of the potential catch in 1989.	V. Haist J. Schweigert
H88-2	Forecasting Pacific herring (Clupea harengus pallasi) year-class strength.	M. Stocker
H88-3	An evaluation of three harvest strategies based on forecast stock biomass for B.C. herring fisheries.	V. Haist
H88-4	Results of the 1988 Barkley Sound herring egg loss study.	C. Haegele J. Schweigert
H88-5	Experimental hydroacoustic biomass estimates in northern B.C.	D. Hay B. McCarter
H88-6	Results of inseason anchor tagging of herring in the Prince Rupert District in 1986 and 1988.	S. Farlinger
H88-7	Offshore herring distribution, length composition and recruitment forecast for the lower west coast of Vancouver Island stock, August 1988.	D. Ware R. Tanasichuk
H88-8	Update on spawn timing prediction work in Barkley Sound.	R. Tanasichuk
H88-9	Biological basis of maturation and wave spawning in Pacific herring (Clupea harengus pallasi).	D. Ware R. Tanasichuk
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G88-4	Flatfish	J. Fargo

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G88-7	Dogfish	M. Saunders
G88-8	Walleye pollock	W. Shaw
G88-9	Slope rockfish	B. Leaman
G88-10	Shelf rockfish	R. Stanley
G88-11	Inshore rockfish	L. Richards C. Hand
3. Invertebrates		
I88-1	Theoretical mortality rates of intertidal clams and their effect on yield estimates	N. Bourne D.J. Noakes G.S. Jamieson
I88-2	A review of survey techniques for intertidal clams.	N. Bourne D. Noakes R. Harbo
I88-3	Recent recruitment to the Tofino Dungeness crab fishery	G.S. Jamieson A.C. Phillips
I88-4	Preliminary studies in the determination of optional management for the exploitation of _Chinocetes tanneri_ off British Columbia	G.S. Jamieson G.D. Heritage D. Noakes M.D. Cook
I88-5	Standardization of effort in the prawn fishery as it relates to biological sampling and escapement management	J.A. Boutillier
I88-6	Results of the 1988 offshore shrimp survey	J.A. Boutillier
I88-7	Review of studies in experimental prawn fishing areas	J.A. Boutillier

Number	Title	Authors
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I88-8	Potential of inorganic elements as markers for prawn populations	J.N.C. Whyte J.A. Boutillier
I88-9	Plankton - Euphausiids (Trawl Fishery)	J. Fulton
I88-10	Review of the abalone fishery in British Columbia	S. Farlinger G. Thomas
I88-11	Geoduck clam (South coast)	R. Harbo K. Hobbs
I88-12	Geoduck clam fishery in northern British Columbia	S. Farlinger
I88-13	Horse clams	R. Harbo K. Hobbs
I88-14	Sea cucumbers	R. Harbo K. Hobbs
I88-15	Green sea urchin fishery - 1987/88	R. Harbo K. Hobbs
4. Salmon		
S88-1	Stock Status and 1988 forecast of Fraser River sockeye	A. Cass W. Saito
S88-2	Stock status and 1988 forecast of Barkley Sound sockeye	K. Hyatt G. Steer
S88-3	Present status of assessment processess for the Skeena and Nass River sockeye and 1988 forecasts	L. Jantz M. Henderson
S88-4	Stock status and 1988 forecast of Rivers and Smith Inlet sockeye	R. Goruk M. Henderson
S88-7	Status of Regional capabilities for coastwide stock identification for sockeye salmon	C. Wood D. Rutherford
S88-8	Stock Status and assessment of study area pink salmon in southern B.C. and the 1988 forecast	L. Hop Wo W. H. Leudke A. P. Gould
S88-9	Stock Status and assessment of southern British Columbia chum salmon and the 1988 forecast	T. Beacham W. H. Leudke S. R. Heizer A. P. Gould M. K. Farwell

Number	Title	Authors
4. Salmon (cont'd)		
S88-10	Stock Status and 1988 forecast of Cumshew Inlet and Bella Colla Chum Salmon.	R. Goruk B. Spilsted C. Murray
S88-11	Assessment of pink and chum production from major Salmonid Enhancement Facilities to 1988.	D. D. Bailey M. D. Plotnikoff
S88-12	An assessment of the 'Expo' coho production experiment.	K. Wilson
S88-13	Stock assessment of early run Skeena River coho salmon and recommendations for management.	R. Kadowaki
S88-14	Preliminary stock assessment of Georgia Strait coho salmon with recommendations for future monitoring, research and analysis.	K. Wilson R. Kadowaki
S88-15	Stock assessment of chinook salmon stocks in southern portion of the Strait of Georgia.	B. Riddell P. Starr
S88-16	Production of chinook and coho salmon from British Columbia hatcheries, 1973 through 1986.	L. Lapi E. Perry C. Cross
S88-17	An inventory of Pacific salmon stocks and the status of stock Assessments in the Pacific Region.	B. Riddell M. Stocker G. Serbic
S88-18	Reconstruction of harvest rates and stock contribution in gauntlet salmon fisheries: application to B.C. and Washington sockeye (Oncorhynchus nerka).	P. Starr R. Hilborn
S88-19	An overview of alternative methods for generating preseason forecasts of Pacific salmon returns.	D. Noakes D. Welch M. Henderson E. Mansfield
S88-20	Description and Statistical Analysis of the Salmonid Mark-Recovery Database.	T. Mulligan J. Schnute L. Lapi B. Kuhn
S88-21	Stock Status and assessment of Fraser River pink salmon and the 1989 forecasts.	D. Blackbourn

Number	Title	Authors
4. Salmon (cont'd)		
S88-22	Stock monitoring and assessment requirements for coho salmon stocks in British Columbia	R. Kadowaki K. Wilson R. Semple
S88-23	Discussion paper on the evaluation of chinook rebuilding.	B. Riddell
S88-24	Exclusion of terminal catches in north coast chinook catch ceiling: A discussion paper.	P. Starr
S88-25	Discussion paper on hatchery add-on in Fisheries Limited by ceilings.	K. Pitre T. Perry

Section II

Advisory Documents

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 88-1

BIOLOGICAL ADVICE ON PACIFIC SALMON

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I. STEERING COMMITTEE REPORT

INTRODUCTION

At its meeting on April 19-20, 1988, PSARC reviewed the Salmon Subcommittee Report as contained in this document.

This document covers stock assessments on most major, net caught, salmon stocks on the B.C. coast. It also covers areas of major conservation concerns in chinook and coho, SEP production, and topical issues on methodology for stock assessments.

The Steering Committee approved the report, but requests the following:

- that stronger recommendations be made regarding the conservation of southern B.C. coho stocks, or elaboration of why these recommendations were not forthcoming from the Subcommittee.
- immediate action should be taken to acquire a minimum set of data annually to improve stock assessments for a set of major salmon stocks, which presently determine our salmon management requirements.

FISHERY IMPACTS

The Salmon Subcommittee report indicates several potential impacts on B.C. salmon fisheries. Increased terminal harvest opportunities are expected on southern B.C. pink (non-Fraser) and chum stocks but the other impacts will involve reduced harvest opportunities. The Subcommittee's recommendation to increase escapements of Fraser sockeye on off-cycle years will require reduced exploitation on some stocks. However, the magnitude of reduction can not be estimated until a program to evaluate cyclic dominance is designed.

Rebuilding production from early run coho in the Skeena River will likely require reduced harvest rates in Statistical Area 3 and 4 fisheries. The Steering Committee also noted concerns in these fisheries for reduced catch of steelhead trout and limitations on chinook catches. More direct attention to the mixed-species nature of sockeye and pink fisheries in these areas seems necessary.

The most immediate impact will be in fisheries harvesting chinook salmon from the Lower Strait of Georgia stock. Five fisheries are principally involved: sport and troll fisheries in the Strait of Georgia, the Johnstone Strait net fisheries, and Central B.C. (areas 6-11) troll and net fisheries. Actions necessary to rebuild this stock have been extensively discussed by the Region's Task Force on this issue but the Subcommittee noted a concern not addressed by the Task Force. Reduced fishing opportunities on chinook salmon in the Strait of Georgia will likely direct more sport and troll effort on coho salmon in the Strait. Coho salmon stocks within the Strait of Georgia and the Fraser River probably cannot sustain increased harvest pressures. The natural spawning component of this stock is depressed relative to their historic escapement levels but recommended escapement targets for these stocks have not been established. Information submitted to the Subcommittee does indicate, however, that reduced harvest on these stocks will likely be required soon.

RECOMMENDATIONS

Each chapter of the Subcommittee report contains recommendations for improving stock assessments. Many of these recommendations may be acted upon by managers of the stocks. The Steering committee endorses these recommendations. However, the Steering committee asks that in future reports, recommendations be identified under three separate topics: advice on harvest and/or escapement levels, advice on information needs, and advice on biological research requirements.

The Subcommittee provided a summary of major recommendations following the review process. These recommendations are endorsed by the Steering Committee, and are recast in four categories as follows:

A. Recommendations on data needs.

1) Review of Region's assessment information

Many stock assessments recommend improved escapement and catch data. The deficiencies in the existing data are clearly reflected in frequent statements that optimal escapement goals and stock productivity are highly uncertain. To rectify these deficiencies a critical review of the Region's assessment information base is required.

The Steering Committee recommends that:

a) the Salmon Subcommittee identifies the major salmon stocks and the minimum information required for management and assessment of these stocks;

b) an evaluation of existing information sources with recommendations on procedures to improve data where necessary should be conducted.

2) Stock identification

Stock identification is becoming a major aspect of salmon fisheries management and assessment in the Region. The

Subcommittee identified that sampling and analytical demands of Regional stock identification programs have exceeded the scope of research programs. However, it is essential to maintain the expertise developed and to ensure consistency in analytical procedures. The Steering Committee recommends evaluating the feasibility of establishing a Regional Stock Identification program and laboratory.

B. Fisheries recommendations

The Steering Committee recommends increasing escapement in off-cycles of the Fraser River sockeye stocks. Rebuilding should proceed within an experimental design to identify factors affecting sockeye productivity and to evaluate production responses due to reduced harvest rates and/or increased enhancement activities. It is recognized that this recommendation is being considered by the Fraser River Sockeye Task Force. The subcommittee and the Task Force should ensure that one process for evaluation of this recommendation is presented for review preferably as part of the PSARC process.

Spawning escapement of Fraser River pink salmon in 1987 was only 1/2 of the escapement target. As soon as practical, the spawning escapement of this stock should be increased to the 6 million spawner goal. When opportunities exist escapements in excess of the goal should be allowed to improve evaluations of the optimal escapement value.

Surplus returns to enhanced and some natural population of the Study Area pink salmon stock are expected. Management and assessment plans should be developed to harvest these surpluses and to evaluate harvest policies in these terminal fisheries.

C. Research recommendations

1) Fish marking

Fin-clipping and coded wire tag programs are essential to chinook and coho assessments and evaluation of SEP production yet several working papers recommend careful evaluation of assumptions involved in these programs. Research programs need to be designed and implemented immediately, to examine assumptions and error sources in these marking programs.

2) Run forecasting

The accuracy of forecasting pre-season abundance of salmon runs is generally very poor. More emphasis must be placed on developing more accurate forecasting models. These models will likely require new analytical procedures and should consider annual variability in marine and freshwater environments.

3) Hatchery survival

Research programs should be initiated to study survival trends and determinants of fish reared in hatcheries; particularly chinook salmon. Parallel studies in natural stocks would be required to evaluate hatchery production rates.

D. Recommendations calling for action in 1988

1) Barkley Sound sockeye stocks

High priority should be given to maintaining documentation and standardized procedures established for aquisition and analysis of assessment and management data.

2) Skeena and Nass River sockeye

Complete studies should be completed to determine the SE Alaskan catch of these stocks. Following completion of these studies a comprehensive assessment of Skeena sockeye stocks, including wild and enhanced components, must be undetaken.

3) Area 9 and 10 (Rivers and Smith Inlet) sockeye

Initiate, and continue routinely, biological sampling of the catch and escapement. The lack of age composition data for Area 10 sockeye has severly limited assessment information on this stock.

4) Lower Strait of Georgia chinook stock

This stock is very depressed and requires immediate conservation actions to protect the stock and rebuild production. Additionally, the Cowichan River stock should be established as an indicator stock for monitoring the rebuilding of the Lower Strait stock.

5) Coho

Early Skeena River coho and naturally spawning coho populations in the Strait of Georgia including the Fraser River require conservation actions. However, Regional needs should be thoroughly reviewed before embarking upon a complex and potentially costly assessment program. A PSARC document should be prepared for the fall Salmon Subcommittee meeting that identifies needs for a regional coho stock monitoring and assessment program. A workshop should be organized to draw upon existing expertise within the Department to ensure the most effective and economical program possible.

6) Hatchery data

Data collected in hatcheries are important to stock assessments and fisheries management. A high priority must be placed on collecting accurate information in these facilities and from the total escapement of enhanced production.

7) Run reconstruction

Run reconstruction methods are widely used in management and stock assessment. A technical document describing the procedure, and providing computer code of a standardized program should be prepared. This document would provide a Regional standard and reduce risk of errors in multiple copies of similar programs.

The following table provides a summary of stock assessment advice presented in the Subcommittee report.

Summary table. Summary of stock assessment advice presented in Salmon Subcommittee Report.

			1987	1988	Absolute[b]	Basis for assessment data[a]			
Species	Stock	Escapement goal	No. of spawners	Forecast return	forecast variability	Catch data	No. of spawners	Escapement goal	Forecast procedure
Sockeye	Fraser:		c		26%	C1	M/R and Visual	S/R, and Policy	Reg. Models
	1988-cycle	1,070,000	922,100	2,900,000					
	1985-cycle	2,500,000	2,077,700						
	1986-cycle	5,500,000	3,723,000						
	1987-cycle	1,500,000	1,915,000						
	(c-previous cycle escapement number)								
	Barkley Sound:			740,000	49%	C1	Quant. Cnt.	Juvenile Model	Reg. Models
	Great Central	200,000	255,000	333,000					
	Sproat	150,000	152,000	296,000					
	Henderson	60,000	29,000	111,000					
	Long Lake	200,000	200,000	445,900	27%	C2	Quant. Cnt.	Policy	Ave. R/S
	Owikeno Lake	1,000,000	521,700	1,158,700	44%	C1	V & I	Policy	Ave. R/S
	Skeena River	900,000	1,400,000	2,284,200	57%	C2	Quant. Cnt.	S/R	Ave. R/S & T/S
	Nass River	200,000	170,000	395,000	30%	C2	and Visual	S/R	Ave. R/S
Pink	Fraser River	6,000,000	3,125,000	Not Yet Available	29%	C1,& CR	M/R and Visual	S/R and Policy	Juv. Prod.
	Southern B.C.:								
	Even Yr. (1986)	1,532,800	1,380,700	3,210,700	75%	CR,	Visual	Hist.	Ave. R/S
	Odd Yr. (1987)	1,798,900	441,600			CR	Visual	spawners	Ave. R/S
Chum	Southern B.C.:								
	Study Area	2,500,000	1,500,000	4,063,000	22%	CR	Visual	Spawning Area	Ave. R/S
	West Coast Van. Island	925,000	301,800	2,115,000	N/A		Visual	Spawning Area	Ave. R/S
	Central B.C.:								
	Cumshewa Inlet	56,000	33,450	228,000	37%	C2,& M/R	Quant. Cnt. and Visual	Spawning Area	Ave. R/S
	Area 8 (Bella Coola)	267,000	130,900	536,000	125%		Visual	Spawning Area	Ave. R/S
Coho	Early run-timing								
	Skeena River	33,000	13,020	Not Developed		C3	Visual	S/R	N/A
	Strait of Georgia	N/A		Not Developed		M/R	Visual and	N/A	N/A
	and Fraser River	N/A		Not Developed		M/R	Quant. Cnt.	N/A	N/A
Chinook	Lower Strait of Georgia	31,000	4,300	Not Developed Except for some Enhanced stocks		C3,& M/R	Visual	Policy	Reg. Model on Big Qualicum Hatchery only

N/A indicated not available.
Footnotes on page 24.

Summary table (cont'd).

[a] Footnote of descriptions for basis of assessment data:

1. Catch Data (catch is usually counted except when run reconstruction methods are used to apportion catch to stocks contributing to mixed-stock fisheries):

C1 - all catches of stock accounted for or estimated with acceptable accuracy.
C2 - majority of catch accounted for but significant problems known to exist (problem may be incomplete catch accounting or inadequate biological sampling).
C3 - minority of catch by stock accounted for, catch in mixed-stock fisheries not determined.
CR - catch estimated by run reconstruction analyses, accuracy unknown.
M/R- tagging and recovery programs used to estimate catch of specific stock (mostly used in enhancement evaluation).

2. Numbers of spawners per year estimated via:

Visual = Counts of spawners by visual count using various procedures.
V + I = Visual counts supplemented by information from Indices of spawning escapements.
M/R = Mark and Recapture procedures consistently employed.
Quant. Cnt. = Quantitative Counts conducted annually by fence or fishway counts, or by electronic countering equipment.

3. Escapement goal established via:

Spawn Area = extrapolation of area used per spawner to total spawning area available.
Hist. Sp. = largest historically observed number of spawners which reproduced itself.
Juv. Models = assessments of juvenile rearing capacity of habitat and extrapolation back to number of spawners required.
S/R = stock-recruitment evaluation of historical data on total returns observed from the estimated broodyear escapement.
Policy = decision to set escapements levels for measurement of changes in production.

4. Forecast of return abundance estimated via:

Ave. R/S = broodyear escapement * average adult return per spawner observed historically * expected age composition in catch (forecast may be altered due to qualitative assessment of environmental quality).
Juv. Prod. = estimation of downstream migrants * expected marine survival * expected age composition in catch (some models now quantitatively accounting for variation in marine survival).
Reg. Models = development of predictive regressions, usually concerning sibling models and oceanographic parameters (i.e.) use of returns of younger age classes to predict returns of older age classes from the same broodyear.
T.S. = time series models using trends in historical data to predict next years returns and/or catch.

[b] Absolute values of plus/minus range of historical forecasts.

II. SUBCOMMITTEE REPORT

INTRODUCTION

The Salmon Subcommitteee met at the Pacific Biological Station, Nanaimo on March 14 - 17, 1988. The Committee considered 19 papers on stock assessment, SEP production and methodology. The objectives, of the meeting were:

1) To review the methods and advice;

2) To develop consensus on stock status and advice;

3) To identify information needs.

This report provides a synopsis of the working papers, reviewers' comments, and the Subcommittee's advice and recommendations.

1. An Inventory of Pacific Salmon Stocks and the Status of Stock Assessment Information in the Pacific Region (Working Paper S88-17):

1.1 INTRODUCTION

The commercial catch of Pacific salmon stocks in British Columbia since the mid-1920s has been quite stable at about 22 million salmon (4 year moving average of actual landings) but in the last seven years the commercial catch has reached historic high levels (Figure 1.1). However, whether the recent production rate is sustainable is uncertain and generates a number of questions about our Pacific salmon resource. For example, how many salmon stocks presently exist and what is their sustainable production potential. This document presented an overview of how many salmon stocks exist in B.C., what their recent escapement levels have been, and, in general terms, summarizes the status of stock assessment information in this Region.

A similar inventory of salmon stocks was presented by Aro and Shepard (1967) for the period 1951-1962. Aro and Shepard (1967) estimated the number of major salmon stocks, based on minimum escapements which had to be achieved once between 1951-1962, and the number of major salmon producing streams, determined as streams having one or more "major" salmon stocks. They identified 347 major streams (1500 streams surveyed in total) supporting 553 major stocks (99 sockeye, 79 pink, 110 chum, 169 coho, 96 chinook). A comparable analysis conducted for the 1976-85 period identifies 394 major salmon streams supporting 599 major stocks (97 sockeye, 120 pink, 129 chum, 135 coho, and 118 chinook; Appendix 1 in Working Paper S88-17).

Records of salmon escapements by species and stream have been recorded annually since 1953; 3901 salmon spawning populations involving the 5 species have been indentified in 1899 streams in British Columbia. In the past 20 years, however, only 1364 (or 35%) of these spawning populations have been consistently surveyed (surveyed 18 out of 20 years). Inventories of salmon spawning populations were summarized by geographic area and species (Tables 1, 2 in S88-17).

Species	# of streams surveyed since 1953	# of streams surveyed consistently	% of streams surveyed consistently
Sockeye	481	146	30
Pink-even year	683[a]	377	55
-odd year	702[a]	267	38
Chum	1027	425	41
Coho	1178	282	24
Chinook	364	115	32

([a]-total number of different streams is 851)

In the vast majority of the geographic area and species strata the minority of streams consistently surveyed contributed the majority of the escapements (Table 3, Working Paper S88-17). Throughout British Columbia, 50% of pink and chum salmon production is contributed by 22% or less of the consistently surveyed streams. The distribution of sockeye escapements is not as strongly skewed to large systems with up to 33% of the streams contributing 50%, and for chinook and coho the distribution is much more even with up to 50% of the streams required to account for 50% of the average escapement. These distributional statistics will, in part, reflect differences in how escapements are estimated in different populations. Quantitative escapements normally exceed more qualitative procedures such as visual counts. Consequently, if escapement to several stocks in a species are determined accurately through counting weirs or via mark-recapture techniques, as in sockeye salmon, then some of the skewness towards a few large systems may simply result from enumeration procedures. The opposite situation likely exists for chinook salmon. Comparing populations on the basis of visual counts likely underestimates the escapements to large river systems more than to smaller systems.

This paper clearly indicates the large number of salmon producing streams in British Columbia and the arduous task that would be involved in annually surveying each system. Escapement surveys have only been consistently surveyed in about one-third of these systems and the survey methodology is not consistent between species, streams and years. However, since the minority of streams surveyed contribute the majority of the production, opportunity seems to exist to substantially reduce coverage but improve surveys in the important systems.

1.2 STOCK ASSESSMENT INFORMATION

Fishing Mortality Information

Since 1951 records of commercial catch by species, statistical area, gear, and time period have been maintained (Wong 1983). Records of catch before 1951 have recently been collated and reported by Argue et al. (1986). Sport and native catch has not been as consistently maintained but, until recently, have been minor components of the total catch.

Accuracy and precision of catch data is simply unknown. Commercial catch records provide consistent records but are unlikely to account for all catches and are known to underestimate the total mortality associated with fishing. Inaccurate catch accounting may result from interception of Canadian salmon in U.S. fisheries and vice versa, error in catch estimation during the landing process, or simply not accounting for all catches in Canada. Underestimation of fishing associated mortalities results from mortalities due to fishing (fish hooked and released, seine squishers, etc.) that are not recorded as catch.

Stock assessments also require allocation of catch to the contributing stocks, biological sampling, and fishing effort statistics. For most stocks in Canada, this is a major limitation in our assessment capabilities, particularly for chinook and coho salmon. Sockeye, pink, and chum salmon are primarily harvested in terminal or near-terminal net fisheries (fisheries close to the river of origin) but chinook and coho salmon are harvested in large mixed-stock hook-and-line fisheries outside of terminal areas. Biological sampling for age composition and size at age in the catch has not been consistent over the catch record period, with the exception of catches sampled by the International Pacific Salmon Fisheries Commission (1947-1984) and the Skeena River management group. Production attributed to broodyears cannot be estimated without age composition of the catch. Fishing effort statistics are fragmented among District offices and historical data on fishing times, areas, and effort are difficult to collect (although the North Coast Division has recently summarized some of this data).

Escapement Objectives

Most escapement estimates are based on visual counts by Fishery Officers or their representative, exceptions to this being counts at weirs or adult tagging programs. These more accurate procedures have largely been limited to major sockeye and pink salmon stocks. Visual estimates are not considered to be accurate estimates of spawning numbers but are treated as indices of trends in escapement. Even then the consistency of these indices between species, streams, and years is uncertain but trends in escapement records do reflect trends in catch or test fishery data when these data have been compared.

Escapement goals or the desired number of spawners for each stock are most commonly established by assuming that production is proportional to spawning area (up to some limit of spawners per unit area). Fishery Officers assess, usually qualitatively, the spawning habitat for each species in a stream and extrapolate to a goal based on the habitat area used by the number of spawners they have observed. Relatively few goals have been set based on juvenile production capacity or optimization of adult returns per spawner (stock-recruitment theory). The notable exceptions being the Skeena River sockeye goal (Shepard and Withler 1958) and some Fraser sockeye stocks although several of the latter stocks may have substantially greater fry rearing capabilities than the stock-recruitment curves indicate.

Whether or not the stated escapement goals truly optimize salmon production is highly uncertain. Most salmon stocks are managed to fixed escapement targets. Consequently the range of escapements necessary to determine an "optimum" escapement range has seldom been observed. In recognition of the uncertainty in escapement goals, more experimental approaches to increasing escapement targets have been implemented for some stocks. Examples are the policy decision to double chinook escapements by 1998 in order to test production capabilities, and the development of life history models for coho and sockeye salmon which incorporate juvenile rearing capacity and population dynamic parameters.

Preseason Forecasts of Abundance

On an annual basis the stock assessment advice for management is the expected allowable catch from a stock. The Region has put very little effort into developing accurate pre-season forecasts and relies on in-season abundance estimates to determine allowable catches. The accuracy of abundance forecasts for 5 major salmon systems with a record of predicted and observed returns range from ± 28 - 53% of the observed returns (Babine sockeye, Smith Inlet sockeye, Fraser pink, southern B.C. chum). Generally expected returns are determined by an average rate of adult returns per spawner, average age composition in the catch, and numbers of spawners in the broodyears. Qualitative adjustments to the forecast are sometimes made to account for variation in freshwater environmental conditions but variation in the marine environment is not considered. Two refinements to this approach involve estimating downstream migrants and using returns of younger age classes to estimate the subsequent returns of a broodyear. Estimation of downstreams migrants is used in the Babine sockeye stock, major Fraser River sockeye stocks, Fraser River pink and chum salmon, and in sockeye stocks assessed by the Lake Enrichment program. "Jack" forecasts or the use of 2 or 3 year-old returns to estimate expected 3, 4, and 5 year-old returns have been used in some sockeye and coho stocks and are being used increasingly to forecast returns of hatchery produced chinook and coho salmon. In a recent more detailed evaluation of forecasting models for Babine sockeye MacDonald et al. (1987) concluded that sockeye returns to the Babine stocks cannot be predicted with sufficient accuracy to be useful to fishery managers. This problem is credited to changes in smolt characteristics over the time period observed and variation in marine survival. The importance of the marine phase has also been recently demonstrated for Barkley Sound sockeye (Hyatt, pers. comm. Pacific Biological Station, Nanaimo).

1.3 DISCUSSION

The utility of stock assessments for most B.C. salmon stocks is limited by deficiencies in our information systems. Figure 1.1 indicated that salmon catches have been increasing over historical levels but this aggregation of catches over species and stocks hides concerns about some species, the concentration of production within a few large stocks, and increasing contributions of salmon produced from enhancement facilities. Clearly this overview indicates a need for improved stock assessment information. The Salmon Subcommittee of PSARC was initiated to conduct rigorous assessments and review our information; several of the problems commented on above will be clearly evident in the following review of the Working Papers.

STOCK ASSESSMENTS

2. Stock Status and 1988 Forecast of Fraser River Sockeye (Working Paper S88-1):

2.1 INTRODUCTION

Sockeye salmon production from the Fraser River support the most valuable commercial fishery in British Columbia. The landed value of the Canadian commercial catch averaged $37 million/yr during 1975-86. The Canadian commercial catch averaged 4.2 million fish/yr during this period. The combined Canada-U.S. catch averaged 5.9 million fish/yr. The average catch in the Indian food fishery was 340,000 fish/yr.

Sockeye spawn in more than 100 tributaries in the Fraser River watershed and rear in more than 20 lakes, about 8 of which have been the major producers. Fisheries on Fraser sockeye salmon are regulated to achieve desired spawning escapements to about 20 stocks. Many stocks are characterized by marked variation in the annual abundance on a 4-yr cycle. Following the collapse of stocks from blockages at Hell's Gate and subsequent overfishing in the early 1900s, stock rebuilding strategies were largely confined to the dominant cycles. The potential for interactions among year classes and the possibility that dominant year classes suppress adjacent year classes remains one of the most controversial issues in west coast fisheries.

2.2 STOCK STATUS

Following the collapse of stocks after the Hell's Gate disaster in 1913, spawning escapements remained at low levels until 1926. In 1926 a relatively large escapement was reported on the Lower Adams River. Since that time escapements were variable but continued to increase (Fig. 2.1).

In the past, management proceeded on the assumption that there are unique recruitment curves for different cycles. The Ricker recruitment model was used since the mid-1970s to estimate the optimal escapement for each stock on each cycle. The biological rationale for estimating the optimal escapement was often based on the more subjective process of setting target escapements that resulted, historically, in a high rate of returns per spawner. In this Working Paper, the Ricker function was fit to spawner and return data to estimate optimal escapement for 22 Fraser stocks.

Our analysis supports the findings of Walters and Staley (1987) and shows that recruitment curves fit to each cycle are biased as a result of fitting curves to short time series of data particularly for stock sizes below the unfished equilibrium (Fig. 2.2). There were no significant differences in the autocorrelations of the deviations from the recruitment curves at a 4-yr lag for any stock. This is evidence against the existence of unique curves for dominant and off-cycle runs. The theory of "cyclic dominance" has profound implications in the management of Fraser River sockeye. To reject the theory implies that Fraser sockeye are over-fished. However, biological interactions among adjacent year classes that rear in the same lake requires further study as the underlying cause of cycles is not known.

Despite the comprehensive nature of the data base there was considerable uncertainty in the fit of the model and the estimates of optimal escapements for many stocks.

2.3 FORECASTS

Methods used in the past to forecast returns were based on the Ricker model and/or several linear regression models. The biological variables used in these regressions varied among the stocks depending on the data available, and included adult escapement, fry, pre-smolt, smolt, and brood year jacks. Environmental data included mean winter air temperatures and river discharge. These variables were then used in various combinations to forecast adult returns. There were generally a number of equations and ultimately a broad range of forecasts to evaluate. The final forecast was then determined by considering the strengths of the various regressions based on the forecasters experience and intuition. Errors in annual forecasts by stock during 1965-85 ranged from -69% to 346%. For the total Fraser population the errors in the annual forecast was much less and ranged from -41% to 50%. We compared the errors in these forecasts with the errors from forecasts based solely on the Ricker model and brood year jack returns. The 10-yr cycle mean return was used as a bench mark in both comparisons(see Fig. 2.3). Forecasts based on the procedures outlined above performed consistently better than forecasts based on either the Ricker model and jack returns but about equal to the 10-yr cycle mean return. The specific procedures used to forecasts the 1988 returns were not presented in the document but were based on the general procedures outlined.

The forecast return in 1988 (2.9 million) is expected to be the lowest return since 1964 due to poor egg to fry survival of the Chilko River stock in 1984. The exploitation rate anticipated for all stocks combined is estimated to be 64% for a catch of 1.9 million. The exploitation rate represents a 19% decline from the 1976-86 cycle mean of 79%. Major contributors to the 1988 fishery are expected to be Chilko River (850,000), Chilko Lake (300,000), Stellako (350,000), Weaver (450,000), Birkenhead (235,000) and early Stuart (135,000) (Table 2.1).

2.4 DISCUSSION

Except for lower Fraser River stocks, where recent declines in returns have occurred, all stocks (where data exists) have remained stable or have shown increases since 1952. However, increases occurred mainly on the dominant cycles. If a single spawner-return curve is appropriate then the opportunity for rebuilding the off cycles is tremendous, and the stocks are being overfished in years of low returns. For example, the escapement goal in 1988 is only 15% of the sum of the optimal escapement estimated for all Fraser stocks assuming one spawner-recruit curve is appropriate. The potential for rebuilding Fraser production cannot be ignored. The level of allowable harvests needed to rebuild stocks depends on the rate of rebuilding and the specific stocks to be rebuilt. The rate of rebuilding ultimately depends on socio-economic as well as biological factors.

2.5 REVIEWERS' COMMENTS

Reviews of this document were thorough and generated substantial debate. Reviews were intentionally requested from a supporter and an opponent to the cyclic dominance theory for Fraser sockeye. The Working Paper estimated a single productivity function per stock across all cycle years. Consequently, one reviewer acknowledged the importance of this procedure and noted its difference from previous management beliefs under the International Pacific Salmon Fisheries Commission. This reviewer was critical of the papers presentation and recommended improved clarity of this important analysis.

The second review acknowledged that the paper properly reflected the current status of Fraser sockeye but disagreed with the use of a single production curve per stock. Given the importance of whether Fraser sockeye productivities vary within stocks between cycle years, the concerns of the second reviewer are summarized. This reviewer noted and/or questioned:

i) that all sockeye stocks are not at equilibrium production and that more stock specific attention is needed in the paper;

ii) whether pooling cycle years into one data set biased the stock-recruitment curve since the data points are not independent observations, and inter-annual variation differs between cycles;

iii) that production of sockeye can be increased through increased cycle-year escapements in some stocks, re-utilization of unused spawning areas, or increased rearing capacity via spawning channels or lake enrichment (depending on the limitation in the stock); and

iv) the author's recommendations to research factors limiting sockeye production, particularly before major changes are made in escapement objectives (i.e. rebuilding off-cycle returns through reduced harvest pressures.)

Basically, this reviewer believes that cyclic dominance does have a biological basis and suggested that ignoring these realities or finding mathematical justification for ignoring them is not prudent. Two consequences of ignoring the cyclic pattern were suggested; total production capacity of

Fraser sockeye will be over-estimated, and consideration of why productivities vary between cycles will be ignored. The degree of difference between the two schools (i.e. that cyclic dominance does or does not have a biological basis) is clearly indicated by a comment by the latter reviewer.

> "...in my view, the concepts presented in this report if applied to the management of Fraser River sockeye stocks are more likely to lead to reduced rather than increased production."

2.6 SUBCOMMITTEE ADVICE

We recommend that rebuilding on the off cycles be initiated in concert with an experimental design to identify factors affecting productivity. This is particularly important in identifying potential interactions among adjacent year classes. Given the uncertainty in the estimates of optimal escapement based on the relationship between spawners and optimal escapements, such as habitat capacity estimates. The specific procedures used to forecast returns should be incorporated into future Fraser River sockeye stock assessments.

The Salmon Subcommittee recognizes the importance of our recommendation to rebuild off cycle runs within an evaluation framework but fully believe that the above debate will continue unless hypotheses are tested. If cyclic dominance has been maintained by harvest pressures then the benefits from rebuilding could be great, too great not to proceed with a test of this theory. The evidence for a biological basis to cyclic dominance does not seem to be convincing enough to risk foregoing the potential benefits. We do however acknowledge the indepth knowledge of the Pacific Salmon Commission staff and suggest close involvement of them during the design of our recommended rebuilding experiment.

3. Stock Status and Forecasts of Barkley Sound Sockeye Salmon with Recommendations for Research and Stock Assessment Activities (Working Paper S88-2):

3.1 INTRODUCTION

Three Barkley Sound Sockeye stocks (Great Central, Sproat and Henderson) are managed within a mixed-stock, mixed-gear fishery operating within Barkley Sound, west coast Vancouver Island. Management objectives are to (i) achieve stock specific escapement goals, (ii) meet the food fish needs of aboriginal peoples resident at Uchucklesit Inlet and especially along the lower reaches of the Somass River, and (iii) achieve a 60% to 40% split of the remaining sockeye to be taken by purse seine and gillnet fleets respectively.

3.2 STOCK STATUS

Total returns of sockeye to Barkley Sound averaged 83,952 fish per annum and ranged from 6,526 to 200,151 for the 70 year period of record prior to 1972 (Fig. 3.1). Beginning in 1973, Barkley Sound sockeye exhibited dramatic increases in total returns which appear to be largely attributable to research, management, and enhancement initiatives involving lake fertilization and escapement optimization. Since 1983, when a peak stock size of approximately 1.6 million sockeye was achieved, there have been four consecutive years of low returns of Barkley Sound sockeye due to low marine survivals associated with recent changes in ocean climate conditions off the coast of Vancouver Island.

Escapement and Catch Trends

Trends in escapement and catch for the most recent decade are summarized below. Escapement and catch trends for Barkley Sound sockeye over the entire period of record (1903-1986) are presented in Working Paper S86-6.

Catch Trends - Barkley Sound has supported an average annual catch of 615,000 fish during the past 10 years. During this same period, the commercial catch (excluding 1986) has varied between 185,000 and 1.1 million fish while the exploitation rate has ranged between 6% and 79%. In recent years the Great Central Lake stock has been the single largest contributor to the fishery (53% of the catch), followed by Sproat Lake sockeye (44% of the catch), and Henderson Lake sockeye (3% of the catch). Given the continuation of below average returns of sockeye to Barkley Sound in 1987, total catch was well below the ten year mean and amounted to just under 200,000 fish. However, this was a significant improvement over 1986 when only 30,000 sockeye were harvested.

Escapement Trends

Henderson Lake - Starting in 1979 and continuing to present, standardized visual counts and mark-recapture procedures have been employed to estimate escapement to Henderson Lake. Escapements have averaged 32,161 sockeye since 1979 (range 5,000 - 56,065). Escapements were low in both 1985 and 1986 but an escapement of 29,000 sockeye in 1987 represents a considerable improvement over the 5,000 fish that reached the spawning grounds in 1986. The 1987 escapement is only 48% of the escapement objective.

Great Central Lake - Major increases in escapement to Great Central Lake after 1972 accompanied increases in total returns associated with lake treatment. Between 1973 and 1986 average escapement increased by more than seven fold (mean 173,238) and peaked with a record escapement of 350,000 sockeye in 1983. Escapements to Great Central exhibited significant declines in each of 1984, 1985 and 1986. However, the 1987 escapement amounted to approximately 255,000 sockeye representing 128% of the escapement objective.

Sproat Lake - Sproat Lake exhibited substantial increases in escapement after 1972. Escapements to Sproat Lake averaged 111,300 sockeye between 1973 and 1986 and achieved a record 250,000 fish in 1973. The escapement in 1984 (89,096) was considerably lower than the most recent 10 year average but escapment improved between 1985-87. Sproat Lake escapement during 1987 amounted to 152,000 sockeye or 101% of the escapement objective.

3.3 DEFINITION OF ESCAPEMENT TARGETS

Escapement targets prior to the late 1970s appear to have been set arbitrarily on the basis of historical precedent and largely without reference to any objective assessment of the productive capapcity of the stocks. Since 1980 escapement targets have been based on estimates of smolt production capacity of nursery lakes and are set at 200,000 sockeye for Great Central, 150,000 for Sproat and 60,000 for Henderson. Recent evidence suggests that escapement targets for Great Central and Sproat sockeye may still be increased by 50,000 to 100,000 fish above existing targets without obvious loss of productive capacity, but these increases have not yet been implemented.

3.4 FORECASTING

1987 Preseason Forecasts

Application in 1987 of the discovery that Barkley Sound sockeye returns vary periodically with marine survival permitted the successful prediction that only 600 to 700 thousand sockeye would return in 1987. Confidence in the 1987 pre-season forecast was weakened greatly by a three week delay in sockeye return timing. In retrospect, the pre-season forecast performed quite well i.e. 600-700 thousand sockeye were predicted to return while approximately 636,000 did return.

Prognosis for 1988

Three independent techniques have been employed to generate return forecasts for 1988. These are the Survival Stanza Method (SStM), the Salinity Survival Method (SSM) and the Sibling Age Class Method (SACM). All three methods account for return year variations in marine survival and should increase the reliability of forecasts relative to those from past years based on returns per spawner or average marine survival. Application of each method for Barkley sound produces return predictions of 490,000 (SACM), 560,000 (SStM) or 740,000 (SSM) sockeye in 1988.

Several considerations support a preference for the SSM forecast of 740,000 sockeye in 1988. Other characteristics to expect in 1988 are (i) returns dominated by 5's in marked contrast to the dominance of 4's in 1987 and (ii) contributions from Great Central, Sproat and Henderson on the order of 45%, 40% and 15% respectively.

3.5 DISCUSSION

1) Objective escapement targets have been defined for each of the three Barkley Sound sockeye stocks; however, optimal escapements have not. Nominal escapement objectives for two of the three Barkley Sound sockeye stocks were satisfied during 1987. However, it is important to recognize that the current escapement objectives set for Sproat and Great Central Lake sockeye represent minimum rather than maximum objectives since both stocks have demonstrated linear increases in smolt output at escapements as high as 100,000 adults over the current levels set for each stock (Fig. 3.2).

2) Recent recognition that recruitment variations have some degree of coherence with long term variations in ocean climate (as indexed by temperature and salinity) has provided the basis for new pre-season forecasting procedures (SStM, SSM). This has aided in identification of a number of testable hypotheses about mechanisms that may be controlling patterns of return variations of sockeye originating from Barkley Sound as well as other rivers and lakes along the southwest coast of Vancouver Island (SWVI).

3) Concerns expressed in last year's PSARC review that changes of responsibilities for acquisition of stock assessment data among BSB, FB and various contractors may influence their utility appear to be well founded. Procedures applied to escapement assessments of Great Central and Sproat sockeye during 1987 exhibited a number of departures from previous years, including (i) a one month delay in installation of the electronic counter used to enumerate escapement into Sproat Lake, (ii) incomplete calibration of the Great Central electronic counter prior to July 21 (iii) omission of sexual identity of sockeye sampled for size and scales prior to August.

3.6 REVIEWERS' COMMENTS

Both reviewers supported the advice provided from this working paper but noted that the emphasis on in-season management processes and review of the 1987 fishery was excessive (the discussion of these management processes have been omitted in this summary of assessment advice). The main concerns of the reviews involved how one forecast was derived from three procedures, and how optimum escapement targets can be established. Future discussions should clarify how the 3 forecast methods are used and whether an objective way to determine one forecast could be developed. Forecast procedures should also consider how to place confidence ranges about the estimate. One reviewer recommended a multivariate study to examine optimal escapement targets. The study would examine relationships between escapements, smolt numbers and characteristics, and freshwater and marine environmental conditions.

It was noted that stock assessments in this area could substantially benefit from closer working relations with the Marine Survival of Salmon Program (MASS) being conducted along the southwest coast of Vancouver Island. Recommendations for coded-wire tagging of sockeye smolts and consistent, standardized data collection were strongly endorsed.

3.7 SUBCOMMITTEE ADVICE

Research should be continued in 1988 to test the relative merits of alternative pre-season forecasts and to investigate the effects of oceanographic conditions on interannual variations in recruitment of salmon and especially sockeye originating from the SWVI. Coded wire tag (CWT) studies should be initiated along with studies sponsored by the MASS program to investigate associations between marine survival variations and variations in the timing, size, and location of origin of migrating sockeye smolts.

Figure 3.2 indicates that these sockeye stocks can sustain escapements greater than the escapement targets. The Subcommittee recommends that escapement increases of at least 50,000 and 100,000 be evaluated when returns to Great Central and Sproat Lake, respectively, allow for these increases. The Subcommittee also supports the reviewer's comments to use multivariate analyses to examine optimal escapement goals.

Continued attention should be given to documentation of and adherence to standardized procedures developed in the past few years for acquisition, assembly and analysis of the several types of stock assessment data. The multiyear data base, currently serving as the basis for management of Barkley Sound sockeye stocks, should be maintained on an annual basis.

4. Present Status of Assessment Processes for the Skeena and Nass River Sockeye and 1988 Forecasts (PSARC Working Paper S88-3):

4.1 INTRODUCTION

Skeena and Nass River sockeye salmon have been the target of major Indian food fisheries and commercial net fisheries for over 100 years (Sprout and Kadowaki 1987). Regionally, the Skeena and Nass rivers are the second and fourth largest producers of sockeye salmon in British Columbia, respectively. The Nass sockeye stock complex is composed of 12 distinct spawning populations. Approximately 76% of the total sockeye production from the Nass River is from the Meziadin Lake system. Enhancement, in the form of a fishway, took place on the Meziadin River in the early 1960s to bypass a series of falls which impeded the passage of sockeye and other salmon species into the major spawning areas. Other major sockeye producers in the Nass are the Bowser, Damdochax, and Fred-Wright/Kwinageese systems which on average account for 14, 4, and 5% of the total sockeye production, respectively.

The Skeena sockeye stock complex is composed of 72 distinct spawning populations although approximately 90% of the total Skeena spawning escapement is usually to the Babine Lake system. Other important Skeena sockeye nursery lakes are Alastair, Lakelse, Kitsumkalum, McDonnell, Kispiox, Bulkley/Morice and Bear/Sustut. During the late 1960s, spawning channels were constructed on two tributaries of Babine Lake; Fulton River and Pinkut Creek. Production from these rivers has been substantially increased from pre-enhancement levels to a point where these two stocks are now the primary target of the commercial fisheries.

Management of the commercial fisheries targetting on Skeena and Nass sockeye in northern B.C. fishing areas is described in detail in the Pacific Region Salmon Stock Management Plan prepared by the Department of Fisheries and Oceans in 1986 and in Sprout and Kadowaki (1987). Indian food fisheries occur in coastal fisheries near Port Simpson and in the estuaries of both the Skeena and Nass rivers. In the Nass River, food fishing extends from just above the tidal boundary to approximately 30 km above the tidal boundary. Skeena food fisheries are conducted in the mainstem from the tidal boundary to the confluence with the Babine River. In addition, food fishing occurs within the Babine system at Kitsegas in the lower Babine River, Nilkitkwa Lake, and in Babine Lake itself. Skeena sockeye are also harvested in food fisheries at Moricetown on the Bulkley River and in the Bear Lake.

4.2 STOCK STATUS

Unlike many stocks in British Columbia the information for stock assessment of Nass and Skeena sockeye is quite good. Catch, escapement, and age-at-return data has been collected consistently and a large portion of the escapements is counted through weirs. However the catch data used in assessments are incomplete because of an uncertain catch of these sockeye stocks by SE Alaskan fisheries. Several tagging programs have been undertaken to evaluate these interceptions but the results have not yet been incorporated into assessments of Nass and Skeena productivities or optimum escapement goals. This work is presently being undertaken. Catch in Alaskan fisheries have been estimated by:

i) interception rates in 1982 and 1983 from an international tagging program;
ii) scale pattern analysis of Alaskan catches (Marshall et al. 1987); and
iii) the average interception rate for years of sampling applied to all other years.

Spawning escapement estimates to the Nass River are derived in several ways. Since 1964, the fishway at Meziadin Lake has allowed nearly complete enumeration of these sockeye. Meziadin Lake sockeye account for approximately 76% of the Nass River sockeye production. Escapement to Bowser Lake, a glacial turbid lake, is estimated by scale pattern analysis of sockeye caught in the Nass River test fishery (Todd and Dickson 1970). Escapements to other spawning areas are enumerated by visual surveys and are of unknown accuracy.

Skeena River sockeye escapement is almost entirely enumerated through the Babine River counting fence which began operation in 1946. Since enhancement of Fulton River and Pinkut Creek sockeye began in 1965, the Babine system has accounted for about 95% of the total Skeena sockeye escapement. Prior to enhancement the Babine system accounted for approximately 85% of the total Skeena River escapement. All other Skeena sockeye producers are enumerated through visual surveys utilizing fixed wing aircraft, helicopters, or foot surveys. These other producers will not be as accurately enumerated as populations above the Babine fence and their total escapements are likely underestimated. Consequently the proportion of the Skeena sockeye accounted for by the Babine system is likely over-estimated but clearly the vast majority of the production in the Skeena system returns to the Babine area.

Escapement to the Nass River has varied between 150,000 and 400,000 over the past decade and no trend is evident. The stated escapement target for the system was 200,000 based on a stock-recruitment analysis. Escapement to the Skeena River has varied from 525,000 to over 2 million during the past decade (the escapement in 1985 exceeded 2 million in order to conserve naturally spawning sockeye stocks) and has not shown any consistent trend. Interpretation of Skeena escapements is complicated by large enhancement facilities on the Pinkut and Fulton rivers. Enhancement commenced on these rivers in 1965. Before returns from enhancement became significant the escapement to these two rivers averaged 134,000 (average 1959-68) but in the last decade escapements have increased to 609,000 on average and the returns are much more variable (ranging from 343,000 to 1,195,400 spawners). These recent returns have contributed 40-70% of the Skeena sockeye escapement, with the exception of a lower return in 1980. The reported escapement target for the Skeena sockeye is 900,000 based on a stock-recruitment analysis by Shepard and Withler (1958).

Catch of Nass sockeye in Canadian fisheries between 1977 and 1986 has averaged 190,000 (range 56,000 - 449,000). Catch of Skeena sockeye in Canadian fisheries over the same period has averaged 1,250,000 (range 509,000 - 2,615,900).

4.3 ABUNDANCE FORECASTS

Forecasting the size of sockeye salmon returns to the Nass River involves taking the product of the average total rate of return to Canada per spawner and the spawning escapement in a particular brood year. This value is then multiplied by the average proportion returning for each age group. This is done for each of the three major age groups (4-2, 5-2 and 5-3 combined, and 6-3) which are then summed to provide the estimate for the total return. The projected total returns to Canadian fisheries and the escapement are:

1988 - 395,000 sockeye,
1989 - 419,000 sockeye.

Historically, this forecasting procedure has been within ±30% of the observed catch and escapement. In using this procedure the interannual fluctuations in survival in both the freshwater and saltwater rearing phases are not accounted for. During the 1983 to 1986 period, this method significantly overestimated the return in three of the four years suggesting that during some phase of the sockeye life cycle, survival was below the average for this stock complex. Alternatively, interceptions of Nass sockeye salmon could have increased in fishing areas outside those used in the stock calculations due to changes in timing or migration patterns.

The forecasting procedure for Skeena River sockeye salmon utilizes a combination of data sources and procedures. In general, there are three techniques. The first method is similar to that used for Nass sockeye. This method is the one most often used. Another forecasting tool used for Skeena sockeye salmon is based on smolt to adult survival estimates (MacDonald et al. 1987). This method is most often used in determining the possible size range of the return and evaluating the freshwater survival of Babine sockeye. The third method used is a correlation between the returns of successive age-classes. However, regression analyses of age 3-2 to 4-2 and age 4-2 to 5-2 returns have a high degree of uncertainty and little confidence is placed in this method for developing forecasts for Skeena sockeye salmon. Forecasts of Skeena sockeye returns have only been within ±57% of the observed return. Two forecasts have been prepared for the 1988 and 1989 Skeena sockeye returns; one based on the same procedure as used in the Nass River and the second from a new time series model (M. Henderson, per. comm., DFO, Vancouver, B.C.). The time series model estimates catch in statistical Area 4 only. These estimates are:

Year	Average return per spawner minus river escapement	Time series model to estimate Area 4 catch*
1988	1,261,800	1,582,900
1989	1,283,700	568,200

*expected and observed returns in 1987 differed by 16%.

These forecasts are only for expected catches in Canadian fisheries.

Despite having an extensive data base (back to 1940) for calculating returns the Skeena sockeye predictions have been less accurate than those for the Nass. Based on the fact that Skeena egg to fry to smolt survival is monitored by the Babine smolt enumeration program one might assume Skeena predictions would be more reliable. This is not the case however. An interesting aspect of both the Skeena and Nass forecasts is that for the years 1983 to 1986 inclusive, the error in the forecasts were in the same direction. That is, when the Skeena forecast was less or more than the actual return the Nass forecast was also less or more than the actual return. This may indicate that these two stock complexes are rearing in similar areas in saltwater and thus subject to the same environmental conditions controlling survival rates.

4.4 INFORMATION NEEDS

The authors noted the need to improve information in several areas:

i) re-assessment of the escapement goals and productivity functions;
ii) more complete accounting for the catch of these stocks, particularly in Alaskan fisheries, and through annual stock identification programs;
iii) evaluate the accuracy of the Skeena and Nass test fishery indices; and
iv) expanding the forecasting methods by including the dynamics of intra- and inter-stock interactions in the marine environment.

4.5 REVIEWERS' COMMENTS

Both reviewers felt the working paper was a useful summary of historical data on Canadian catches and escapement for these stocks but noted the need for more emphasis on biological assessments. Some of this was intentionally omitted as the catch data are under review. However, future assessments should address:

i) the analytical basis for the escapement targets presented;
ii) more details on escapement distribution amongst sockeye populations and escapement trends by stock;
iii) a separate evaluation of the enhanced production from Pinkut and Fulton rivers; and

iv) an explanation of how the Skeena forecast is decided on when several methods used provide conflicting estimates.

4.6 SUBCOMMITTEE ADVICE

Analyses to support the escapement goals stated were not presented in this working paper. Consequently, stock recruitment analyses of the data presented were conducted by the Subcommittee.

A Ricker-type production curve fit to the Nass River sockeye data (broodyears 1964-80) confirms the goal of 200,000 spawners but this goal does not account for the potential biases in these analyses. The bias-corrected escapement target was estimated to be 235,000 spawners (Fig. 4.1). These analyses should be re-assessed when the SE Alaskan catch of Nass River sockeye has been estimated.

Assessment of the Skeena sockeye date involved re-analyzing the data presented in Shepard and Withler (1958) and the data presented for broodyears 1958 through 1981. The former analyses were re-analyzed because the 900,000 goal was derived by a 5-point smoothing procedure, and may not be consistent with procedures presently used to calculate Ricker parameters. The bias-corrected optimal escapement goal (for the period 1908-52 broodyears) was 859,000 spawners, very close to the originally estimated goal. However, estimates for the more recent period indicate a lower optimal escapement goal and are complicated by the presence of enhanced production (Fig. 4.2). Estimates of the sockeye production from the spawning channels and adjacent rivers were provided by C. West (pers. comm., DFO, 555 w. Hastings St., Vancouver, B.C.). These preliminary analyses indicate that the major change between the more recent and the previous data is a substantially lower escapement goal for the naturally spawning stocks. These results require more thorough assessments of what the proper escapement goal is and what the impact of the enhancement facilities have been on natural stocks. These future analyses must account for the SE Alaskan catch of Skeena River sockeye.

Specific advice from this summary is:

1) An allowable harvest of 175,000 Nass sockeye is expect in 1998.

2) Expected catch of Skeena sockeye salmon in Area 4 during the 1988 season is 1,280,000 or 1,582,900 depending upon the forecast method used. Either prediction will require a fishing plan that will be at the maximum harvest level developed in the early 1980s. Due to the mixed stock nature of the Area 4 net fishery a maximum of four days fishing per week, which results in an exploitation rate of 50 to 55%, has been adopted. This management strategy is used to control the incidental harvest of chinook, coho, chum, and some less productive sockeye stocks.

3) Studies to estimate the Alaskan catch of Nass and Skeena sockeye must be completed and extended back in time as far as is practical. (Adult tagging programs in SE Alaska extend back over 50 years but the consistency of their escapement records is uncertain.)

4) A detailed re-evaluation of escapement goals and enhancement impacts are required in the Skeena River.

5) Investigations to improve forecasting methodologies by incorporating environmental variables should be initiated.

The request to evaluate the test fishery indices will be considered in the selection of the 1988-89 PSARC tasks. There also seems to be a need to examine a multiple-species approach to managing salmon and steelhead in these rivers.

5. Stock Status and 1988 Forecast of Rivers and Smith Inlet Sockeye Salmon (PSARC Working Paper S88-4):

5.1 INTRODUCTION

Sockeye production in Statistical Areas 9 and 10 on the Central Coast of British Columbia originates primarily from Owikeno Lake in River's Inlet and Long Lake in Smith Inlet, respectively. Since 1970, the combined Area 9 and 10 sockeye catch has represented 75% of the total sockeye catch from the Central Coast (Areas 6 - 10) and 13% of the total British Columbia sockeye catch. This catch is taken almost entirely in terminal gillnet fisheries; there are no significant Native food fisheries.

Catch in both areas declined from 1968 to 1982 but increased slightly in recent years (Fig. 5.1 and 5.2). In Area 9, the decline in catch is associated with reduced exploitation rates from 1979 to the present which resulted from management efforts to increase escapement (Fig. 5.3). No clear trends in exploitation rate are evident for Area 10 in recent years (Fig. 5.4).

5.2 AREA 9 STOCK STATUS

Escapement Trend

The total sockeye return to Area 9 in 1987 was 920,300 which is 35% higher than the past 10 year average. The sockeye escapement in 1987 of 521,700 was also 8% above the past 10 year average. Escapements have been increasing since the early 1980s as a result of revised management objectives. Sockeye escapements are estimated by visual counts in 10 tributaries to Owikeno Lake. In most years, the four largest spawning areas account for the majority of the total spawning escapement.

Escapement Target

In 1979, a sockeye escapement target for Area 9 was set at 1,000,000 because stock assessment data indicated that the average escapement of 375,000 in previous years (1969-1978) had been suboptimal. The 1979 assessment data were inadequate to determine an optimum escapement and it was recommended that the new target be adopted to provide data which would permit assessment of the optimum in the future. Escapements and catches have increased since 1979 but an optimum escapement has not yet been determined. One difficulty in assessing optimal escapement is that age composition data are not available from the catch so that estimates of total return by brood year (required for stock-recruit analysis) may be unreliable.

5.3 AREA 10 STOCK STATUS

Escapement Trend

The total sockeye return to Area 10 in 1987 was 394,700 which is 23% higher than the past 10 year average. The sockeye escapement in 1987 of 200,000 was also 26% above the past 10 year average and conforms to an increasing trend since 1979. Sockeye escapements have been estimated by weir counts on the Docee River below Long Lake since 1970; for practical purposes, these counts can be considered to be very accurate. Prior to 1968, escapements were estimated from visual counts on the major spawning areas. There are only two spawning areas, the largest of which accounts for 75% of the spawners.

Escapement Target

In 1979, a sockeye escapement target for Area 10 was set at 200,000 because stock assessment data indicated that the average escapement of 98,900 in previous years (1969-1978) had been suboptimal. The 1979 assessment data were inadequate to determine an optimum escapement and it was recommended that the new target be adopted to provide data which would permit assessment of the optimum in the future. As in Area 9, escapements and catches have generally increased but an optimum escapement has not yet been determined. Again, a serious problem for assessing optimal escapement is that age composition data are not available from the catch so that estimates of total return by brood year may be unreliable.

5.4 FORECASTS FOR 1988 AND 1989

Forecasts for total sockeye returns in 1988 and 1989 are 1,158,747 and 746,614 fish, respectively, in Area 9, and 445,855 and 402,979 fish, respectively, in Area 10. Forecasts for both areas are based on age-specific average rates of return multiplied by escapement estimates for the appropriate brood years. Forecasts developed for 1984-1987 using this procedure have consistently overestimated returns to Area 9 by an average of 44%; forecasted returns to Area 10 were too high in three of the four years, and overall, erred by 27%.

An alternative regression procedure (Henderson et al. 1987) has also been developed to forecast returns to Area 10. This procedure provided more reliable estimates for 1984 and 1985 but very inaccurate estimates for 1986 and 1987. Forecasts of total returns to Area 10 in 1988 using the regression procedure range from 517,000 ± 141,000 to 737,000 ± 172,000 where 1986 data has been included or excluded from the analysis, respectively.

5.5 DISCUSSION

The authors of this document conclude that additional research is required to determine optimum escapements and to develop reliable forecasting procedures to assist managers achieve escapement goals in both Areas 9 and 10. They stress the importance of obtaining age composition data from catches. Both stocks are exploited by terminal fisheries and accurate escapement data are available for the Area 10 stock. Thus, assessment of stock status and optimal escapement should be relatively straight forward.

The experimental increase in escapement targets since 1979 has failed to provide the information required to evaluate escapement goals. Recent returns have been less than expected and the authors attribute this to a recent decline in marine survival which has been coincident with the increase in escapement.

A small harvestable surplus is expected in Area 9 in 1988. A surplus of 246,000 sockeye is expected in Area 10 in 1988. However, it should be noted that forecasts have tended to be overly optimistic in recent years for both stocks.

5.6 REVIEWERS' COMMENTS

Both reviewers noted the essential need to undertake age composition sampling in commercial fisheries in Areas 9 and 10. Opportunity for excellent assessments of Area 10 - Smith Inlet sockeye was noted but more sampling and analyses are necessary.

5.7 SUBCOMMITTEE ADVICE

It is unfortunate that age composition data from both the fisheries and escapements in Areas 9 and 10 are inadequate to properly analyse the stock-recruit relationship for these stocks. Catch and escapement data, especially for Area 10, appear to be very reliable compared to most other stocks and a stock-recruit analysis should be very informative.

Preliminary stock-recruit curves fitted to the data in this report (brood years 1966-1981) are difficult to interpret (Fig. 5.5 and 5.6). The stock-recruit curve for Owikeno Lake indicates that the escapement target of 1,000,000 may be too high. However, the model fits the data poorly and contrasts production levels observed historically (i.e. pre-1960 period). Additional years with high escapements would facilitate future analyses. Long Lake in Area 10 was enriched with fertilizer in 1978-1980 and again in 1982-1987. If data for the years of enrichment are excluded from the analysis, the optimal escapement appears to be less than 200,000 (dotted line in Fig. 5.6). As the authors point out, data for both stocks may be based on unreliable estimates of age composition.

Additional information on freshwater productivity for Long Lake (associated with lake enrichment experiments) has been analyzed to assess the relationship between spawning escapement and smolt production and thus, to indirectly estimate the optimal escapement target for Area 10 (Fig. 5.7).

This analysis is free from age composition errors but assumes that hydroacoustic estimates of smolt abundance are reliable. Nevertheless, a similar optimal escapement of between 100,000 and 150,000 spawners is indicated, depending on the expected smolt-to-adult survival. Given the quality of catch and escapement data for Area 10, and the availability of estimates of smolt abundance with and without lake enrichment, a more sophisticated analysis of the status of Area 10 sockeye stock should be possible.

Estimates of smolt-to-adult survival based on hydroacoustic estimates of smolt production in Long Lake do not support the authors' argument that marine survival has declined in recent years. In fact, the analysis of smolt production in Fig. 5.7 suggests that sockeye production in Long Lake is limited by freshwater factors, even under lake enrichment.

It is strongly recommended that:

1) Adequate age composition data be collected from future catches and escapements in both areas.

2) Data collected in association with lake enrichment in Long Lake should be analysed in greater detail to determine whether the existing escapement for Area 10 is appropriate.

3) More variable escapements should be allowed in Area 10 to improve evaluations of optimal escapement values.

6. Stock Assessment of Chinook Salmon Stocks in the Southern Portion of the Strait of Georgia. (Working Paper S88-15):

6.1 INTRODUCTION

Chinook salmon (Oncorhynchus tshawytscha) in the southern portion of the Strait of Georgia utilize 17 rivers from Toba Inlet south on the mainland (excluding the Fraser River) and from Big Qualicum River south on Vancouver Island. In aggregate these stocks are referred to as the Lower Georgia Strait stock (LGS). The majority of the production from this stock comes from three rivers managed for naturally spawning chinook (Squamish, Cowichan, and Nanaimo) and three rivers predominated by hatchery production (Big Qualicum, Little Qualicum, and Capilano). All of the rivers managed for natural stocks also have smaller scale hatchery production in them. Chinook in the Capilano River are of Big Qualicum origin. Information on the chinook populations in the mainland inlet rivers except the Squamish River is very limited. Escapement information from these rivers (six in statistical Areas 15 and 16) is highly variable and, recently, very few spawners have been recorded. These rivers are glacial and have peak flows in the summer period when chinook are believed to enter the rivers, consequently spawner enumeration is difficult. Since very little is known about these stocks, they will not be discussed in this paper.

The significant spawning stocks on Vancouver Island are fall chinook returning to spawning grounds in late August through October. Entry into freshwater is frequently delayed by low water due to summer draughts in this area. However, the rivers on the Island supporting chinook salmon are mostly medium sized rivers that are lake fed and have partial flow control. Spawning normally occurs in late October till mid-November. Squamish chinook have a slightly early return timing and are referred to as late-summer migrants, returning from July through September. Small stocks of spring chinook are also known in the Nanaimo and Cowichan rivers. These stocks are presently very depressed in population size.

Chinook from this stock primarily mature as 3 and 4 year olds, 5 year olds comprise less than 5% of the returning adults. Ages at return for the Big Qualicum chinook (Fraser et al. 1983; averages for 1959-72 return years) were: 21% jack male-2 year olds, 28%-3 year olds, 49%-4 year olds, and 2%-5 year olds. Age at maturity does vary significantly between sexes: mean age at maturity for males was 2.9 years but in females increases to 3.9 years.

A major limitation to chinook stock assessment is that catch by stock is unknown unless a portion of a stock is tagged. Assessment of LGS chinook is heavily reliant upon the coded-wire tagging of juvenile chinook produced in enhancement facilities. However, in applying this data to natural chinook stocks we are assuming that hatchery rearing does not influence ocean distribution or exploitation patterns. Information on freshwater production rates, age and sex of spawners, and fecundity is equally reliant upon the Big Qualicum enhancement study (Fraser et al. 1983).

6.2 STOCK DISTRIBUTION

The Lower Strait of Georgia chinook stocks have a limited northerly migration into central B.C. but the majority of the harvest is within the Strait of Georgia.

Five fisheries consistently account for 89-92% of the recoveries of LGS chinook over the 4 broodyears examined (1979-82). These include:

	STOCK (% of recoveries)			
FISHERY	Big Qualicum	Squamish	Nanaimo	Cowichan
Georgia Strait sport	47	53	47	56
Georgia Strait troll	11	3	16	16
Johnstone Strait net	16	5	18	14
Central B.C. troll	8	8	8	2
Central and Northern B.C. net	7	23	3	3
Sum	89%	92%	92%	91%

These distributions are consistent between broodyears but differ between ages (detailed in Working Paper S88-15). The distributional data also indicates that the two more southerly stocks on Vancouver Island (Nanaimo and Cowichan) have a greater portion of their harvest taken within the Strait than the Big Qualicum stock. Further, in more recent broodyears a larger portion of the total catch by stock has been taken by the Strait of Georgia sport fishery.

6.3 CATCH AND ESCAPEMENT

Catch by stock is not available for chinook salmon. Consequently evaluations of production from these stocks is restricted to trends in escapements and catch in the fisheries known to exploit these stocks (the distribution area). Escapement to the natural spawning components of the 17 populations has declined by 80% since 1955 (based on the most recent 3 year average of escapements; Fig. 6.1). Escapements to the Nanaimo, Cowichan, and Squamish populations have declined by 88% based on the same criteria. The greater decline is because hatchery escapements have contributed to natural spawning in some systems.

Escapement to the LGS stock in 1987 was only 14% of the escapement target. The current target is 31,000 total spawners, excluding 2 year old males (jacks). This target was established as twice the average escapement between 1979 and 1982. This formula was agreed to by DFO scientists and managers in 1982 as an interim target with the goal of increasing production by a measurable level. This process was initiated to investigate escapement levels needed to optimize yield from chinook salmon stocks.

All escapement estimates presented (excluding the Big Qualicum River) were based on visual counts by field staff. These visual counts are treated as indices of the trend in escapement and are known to be of variable accuracy regarding how many chinook actually spawned. The authors support Healey's (1982) conclusion that escapement data is indicative of the trend in escapement but caution that recent escapement surveys are likely more accurate than earlier ones. More effort is being spent on determining chinook escapements and the participation of Salmonid Enhancement staff during brood stock collection has provided a more consistent approach to escapement estimation, particularly in the major LGS populations.

Catch in the distribution area of this stock rose dramatically until 1978 but has decline sharply since (Fig. 6.1). The catch in 1987 was only 27% of the peak catch in 1978. The trends in declining catch and escapements (excluding Area 15 and 16) are correlated (correlation co-efficient = 0.62). Many chinook stocks other than the LGS stock are known to contribute to these fisheries but the close relationship of catch and escapement to LGS stocks and the known ocean distribution of this stock strongly suggests that the LGS stock used to make significant contributions to these fisheries.

6.4 EXPLOITATION RATES

Exploitation rates on the LGS stock are estimated to exceed 80% (i.e. the fishing mortality divided by the fishing mortality plus the escapement by broodyear). Exploitation rates on Big Qualicum chinook have been monitored since the 1971 broodyear. Over this period the exploitation rate has varied between 76 and 86% but has not shown any consistent trend.

Cohort models similar to the model by Hankin and Healey (1986) are used to determine exploitation rates. Catches are expressed in adult equivalents to account for changes in size limits in fisheries over time. Adult equivalent catch is the observed catch reduced by a factor to account for the probability of a fish returning to spawn if it had not been caught.

Exploitation rates have been estimated with and without associated fishing mortalities but the exploitation rates including these losses should be used in assessments. Associated fishing mortalities include estimates of chinook mortalities due to catch-and-release of sub-legal sized chinooks and non-reported catch of small chinooks in seine fisheries. It is essential to remember that in applying these exploitation rates to natural stocks that we are assuming that hatchery rearing does not influence vulnerability to fisheries or age at maturity compared to the natural stocks. These exploitation rates are likely conservative for the LGS stock aggregate since the natural stocks south of BQR are harvested more heavily in the sport fishery and have terminal harvest in-river. Concern about incomplete coded-wire tag recoveries in the escapement to BQR may, however, offset these effects. Exploitation rates estimated for the BQR stock would exceed those sustainable at maximum production levels from naturally spawning stocks.

6.5 PRODUCTIVITY

Productivity estimates for the naturally spawning portion of the LGS stock were developed using:

i) the target escapement (assumed to equal the optimum escapement);
ii) the trend in escapement counts; and
iii) the exploitation rate on BQR stock (assuming an average value over the time period used 1975-87).

This analysis (described in S88-15) indicates that the exploitation rate at optimum production could be as high as 75%. However, this procedure is sensitive to assumptions about the three sets of input data (i-iii above). A sensitivity analysis was presented which indicates that the productivity rate estimated is probably at the high end of the range of likely values. True exploitation rates at optimum will likely be between 65 and 75%. Estimates of returns per spawner at optimum escapement levels could not be refined to a range smaller than 5.5 to 8.5 adult equivalent returns per spawners (Ricker 'a' values of 1.7 to 2.15). Management actions regarding rebuilding the abundance of this stock should account for the uncertainty associated with the productivity parameters for this stock.

Production from chinook enhancement activities in the LGS stock area is substantial. Five major hatcheries (Big Qualicum, Little Qualicum, Puntledge, Chemainus, Capilano) and 6 smaller projects release chinook from this region. Releases of chinook, excluding fry, has increased from about 500,000 chinook in the 1971 broodyear to over 16 million in the 1986 broodyear (including Puntledge releases because of BQR transplants and the contribution of Puntledge chinooks to fisheries within the Strait of Georgia). Contributions to fisheries from these releases have varied from 23,500 chinook (for the 1974 broodyear when Capilano hatchery lost all their chinook) to over 70,000 chinook from the 1978 broodyear. However, recently increased smolt releases are not resulting in proportionate increases in contributions. Changes in fishing regulations (size limits and catch ceilings) explain some of the reduction in rate of contribution but the time series of releases from Big Qualicum hatchery indicates that survival to adult has been lower in recent years (Fig. 6.2). Survival information for the smaller facilities is not available since tag recoveries from the escapement are not collected. The reasons for the poor survival at BQR are not known. It is also not known whether wild chinook stocks have experienced a similar decline in survival. However, simulation studies have suggested that wild survivals have declined but not as dramatically as hatchery survivals.

6.6 1988 FORECAST OF BIG QUALICUM RETURN

Although it is not possible to forecast the 1988 returns of the naturally spawning Lower Georgia Strait stock, a forecast has been prepared for the 1988 return to the Big Qualicum River, including the natural spawning fraction. This forecast is based on a sibling regression model constructed from survivals at age data calculated from tag recoveries. Since 1981, the tag returns have underestimated the actual escapement to the Big Qualicum fence by about 40%. A shortfall of this magnitude may be due either to the naturally spawning fraction in the river (which would be unmarked), to errors in recovering tags, or to a combination of the two effects. Therefore, the forecast was adjusted upward to reflect this average bias. A similar forecast prepared for the 1987 return year was 7% less than the actual return.

The 1988 forecasts is for nearly 10,000 spawners to the river excluding precocious males (jacks). The forecast predicts 75% age 3, 21% age 4 and 4% age 5 fish in escapement. However, the forecasts for the age 3 fraction of the population (1985 broodyear) is at the lower limit of the regression model and there is a great deal of uncertainty in the quality of the forecast for that age class. It is quite possible, given the extremely poor returns for that broodyear in 1987, that the actual return may fall short of the predicted return and the hatchery may not meet their egg requirements.

6.7 REVIEWERS' COMMENTS

Only one thorough review was received. This reviewer agreed with the methodologies and conclusions but noted that assessment of this stock has become very detailed. Consequently a more comprehensive scientific review would require a significant time allocation. The second reviewer's only comments pertained to the relative importance of age 3 and age 4 females to the reproductive potential of the stock (more data will be collected to assess the reproductive effort of these age classes).

6.8. SUBCOMMITTEE ADVICE

The severe decline in escapement and loss of catch in fisheries known to harvest the LGS stock clearly indicates that these populations are below stock sizes need to maximize production from the LGS stock. Exploitation on the stock exceeds 80%; continued exploitation at this level will drive the natural stocks to very low levels of sustained production. Exploitation rates at about 75% may be sustainable once the stock is at optimum escapement levels but even this rate is believed to be excessive. Exploitation rates between 65 and 70% are likely needed to rebuild this stock and sustainable exploitation rates after rebuilding will likely be about 70%.

1) The naturally spawning component of this stock requires immediate conservation actions to restore production. Exploitation rates on these stocks should be lowered by 10 to 15 percentage points. Returns in 1988 will remain very depressed in abundance.

2) Returns in 1988 to the Big Qualicum Hatchery should meet egg requirements at this facility but are unlikely to provide surplus eggs for other hatcheries. However, the forecast seems optimistic and is uncertain because of the very low return of age 2's in 1987. The return should be closely monitored and plans for the use of eggs should allow for contingencies in case the return is not as large as indicated.

3) Research is required to reduce the uncertainty concerning the productivity of this chinook stock. If the present productivity estimates are too high, then greater reductions in the harvest will be required to rebuild the stock. Research programs needed include:

   a) validation of assumptions in the coded-wire tag program; particularly the assumption that hatchery tag groups are representative of natural stocks;

   b) development of a habitat basis for estimating escapement targets;

   c) monitoring exploitation rates on the Cowichan River stock (Exploitation patterns on the Cowichan stock indicates that it could serve as a common denominator to the rebuilding of all LGS stocks. Monitoring exploitation rates will necessitate accurate escapement estimation and tag recoveries from the escapement. The Cowichan chinook stock should serve as the key or indicate stock for evaluation of the rebuilding program.);

   d) increased escapement monitoring on the mainland side of the Strait of Georgia, particularly establishing a consistent index for the Squamish River; and

   e) examination of the interactions between hatchery-reared chinook and wild chinook, particularly whether hatchery-reared chinook have equal spawning success with wild chinook.

4) In light of the importance of this assessment and the use of new methodologies, the Subcommittee recommends a comprehensive external review of methodologies and recommendations presented.

7. Stock Assessment of Early Skeena River Coho Salmon and Recommendations for Management (Working Paper S88-13):

7.1 INTRODUCTION

The Skeena River, located in north coastal British Columbia, is the second largest salmon producing watershed in British Columbia. Coho salmon production ranks third in abundance among the five salmon species in the Skeena. Pink and sockeye salmon are by far the dominant species while coho and chinook are more abundant than chum salmon. Net fisheries targeting on pink and sockeye and ocean troll fisheries are the primary harvesters of Skeena River coho while in-river Indian food fisheries and sport fisheries harvest smaller shares. The total catch of this stock for the years 1956 to 1987 is presented in Figure 7.1.

The upper Skeena River and Bulkley River coho stock was highlighted as one of three B.C. coho stock groups with documented conservation concerns in the 1986 Pacific Stock Assessment Review Committee (PSARC) Annual Report. These stocks are assumed to be earlier in run timing than lower Skeena coho stocks and migrate at the same time as sockeye and pink salmon which are the target species of the river mouth net fishery. There is no directed management for this stock in either the troll or net fisheries.

Early timing Skeena coho are believed to be produced primarily from upper Skeena and Bulkley River streams. Major component stocks include the Morice River, a tributary of the Bulkley, and the Babine and Bear Rivers, which are tributaries of the upper Skeena River.

7.2 STOCK STATUS

Escapement Trends

Declining trends have been documented for spawning escapement as estimated by fishery officers (Fig. 7.2), the Skeena test fishery index (Fig. 7.3) and the Babine fence count of coho (Fig. 7.4).

Escapement Goal

The point estimate of maximum sustained yield (MSY) escapement, calculated from a stock recruit analysis, is 33,000 spawners with a 95 percent confidence range of 27,000 to 40,000. Varying assumptions about fishery interception rates and therefore total stock size did not appreciably affect this estimate.

This spawning escapement goal was reached in all but one of the first sixteen years of the data record, and only seven times in the next sixteen years. In the most recent cycle (1985 to 1987) the average escapement was only 61 percent of the MSY level, indicating an acceleration in the rate of decline of the stock.

A key feature of the stock recruit analysis was the use of the Skeena test fishery coho index (1956 to 1987) to calculate escapement past the commercial fishery. This index is believed to be a more reliable and consistent indicator of escapement than the historical record of fishery officer estimates. Assumptions about ocean harvest rate and terminal stock composition were tested by bracketing point estimates, and the results are noted above. A major limitation of this analysis is that year to year variability in contributions to these fisheries was not considered.

1988 and 1989 Forecasts

A continuation of recent exploitation rates and spawning escapement levels should cause a steady decline in abundance. The prognosis for the next cycle (1988 to 1990) is poor given the spawning escapements in the brood years.

Forecasts based on factors other than spawning escapement level (environmental conditions, inter-specific interactions, etc.) have not been developed to date.

7.3 DISCUSSION

Given recent spawning escapement levels, the declining trend of early timing Skeena River coho stocks is expected to continue unless significant management actions are taken. The approximate timing and distribution of coded wire tagged hatchery stocks from the Kispiox and Babine Rivers could be used as a guide for such actions in the absence of information on specific wild stocks. Enhancement options may complement and accelerate rebuilding by fishery management actions and should be considered as part of an over-all rebuilding strategy.

7.4 REVIEWERS' COMMENTS

At the suggestion of both reviewers, the stock recruit analysis was redone using all 28 brood years rather than a subset of 25 which the author selected as being the most representative of the stock aggregate. MSY escapement is now 3,000 less than in the original analysis. This chapter of this Subcommittee report contains this revision.

Other comments are less substantive and should not affect the conclusions and recommendations contained in the summary. Both reviewers complemented the thorough analysis and supported the recommendations presented.

7.5 SUBCOMMITTEE ADVICE

Conservation actions are needed to increase escapement and production from this stock. Discussions to examine rebuilding options should commence immediately.

In support of a rebuilding program it is extremely important that efforts are made to collect information on catch distribution and exploitation rate on key stocks throughout the Skeena watershed. As a minimum, one early run and one late run stock should be monitored.

Continuation of the Skeena test fishery until the end of September for a minimum of three years is recommended. This would provide valuable information on the relative magnitude of the early and late timing components of the Skeena coho run. In combination with coded wire tagging programs, this extension could identify alternative options for managing those stocks with run timing that spans both time periods.

A spawning escapement goal of 33,000 coho is currently the best estimate of MSY escapement for the early run Skeena River coho stock. Taking into account a catch of approximately 3,000 fish in the in-river Indian food fishery and 1,000 fish in the in-river sport fishery, a river mouth escapement goal of 37,000 fish is recommended. This is equivalent to 68 coho index units past the Skeena test fishery by August 24th.

8. Preliminary Stock Assessment of Georgia Strait Coho Salmon with Recommendations for Future Monitoring, Research and Analysis (Working Paper S88-14):

8.1 INTRODUCTION

Coho salmon are produced in over 200 streams in Georgia Strait and 180 streams in the Fraser River. Spawning escapements have been in the order of 240,000 (during the 1950s) and are currently estimated at 120,000 (1980s). These stocks are caught primarily in troll and sport fisheries in Georgia Strait, troll fisheries on the west coast of Vancouver Island (WCVI) and the south central coast and in net fisheries in Johnstone Strait and Juan de Fuca Strait. The catch in these fisheries (excluding the WCVI troll fishery) is presented in Figure 8.1.

The coho catch by all gear types has declined in the 1980s from historic levels. The troll catch is currently (1980s average) at about one half of the 1950s level.

The sport catch since 1972 appears to be relatively stable, with 1980s levels about 12 percent below 1970s levels. Recent catches (1985 to 1987) are higher than the decade average.

The catch of coho has also declined in the four major net fisheries (net catches in Areas 11-20, 29) which harvest Georgia Strait coho stocks. In aggregate, current net catch is 57 and 59 percent of the 1950s and 1970s levels respectively. Current net fishery catches are restricted almost entirely to incidental levels.

Canadian hatchery contributions have increased from about 10 percent of the total catch (all gear combined) in the mid-1970s to about 25 percent in recent years. When these contributions are subtracted from the catch of each of the three gear types there is a noticeable declining trend over the eleven year time span of the data. Since U.S. hatchery production was also increasing during this period, the decline of wild fish in the catch is probably much more pronounced. Comparisons of recent catches adjusted for hatchery contributions with catches in the 1950s and 1960s would show steep declines.

The coho stocks dealt with in this paper include all stocks within Statistical Areas 13 through 20 as well as 28 and 29. This area stretches from the lower end of Johnstone Strait south to Juan de Fuca Strait and includes the Fraser River. This aggregate coho stock was highlighted as a conservation concern by PSARC in 1986.

8.2 STOCK STATUS

Escapement Trends

Total spawning escapement in Strait of Georgia streams have declined only slightly since the 1950s and 1960s. However, once escapements to hatchery streams are subtracted, there appears to have been a significant decline, to about 43 percent of historic levels (Fig. 8.2).

Fraser River spawning escapements have also declined from an average of 81,000 in the 1950s and 1960s to an average of 52,000 in the 1980s (Fig. 8.2). Although low escapements were experienced in the earlier periods, they were not as persistent as they have been in recent years.

Escapement Goal

There is currently no escapement goal for Strait of Georgia coho stocks. The future establishment of a goal may be related to habitat capacity evaluations and/or an escapement indexing system.

Exploitation Rates

Although there has been no apparent trend since the late seventies, exploitation rates on Strait of Georgia hatchery coho have been consistently in the 70 to 85 percent range, with recent averages ranging from 75 to 81 percent. Exploitation rates for the Big Qualicum River hatchery are believed to be the most reliable because of a weir on the river allowing a consistent escapement sampling program (Fig. 8.3)

The above noted exploitation rates are very high for wild salmon stocks. Studies on coho have generally recommended an exploitation rate of about 70 percent to produce maximum sustainable yields. Although wild coho stocks might not be harvested by fisheries at the same rate as hatchery fish, these high rates remain a serious cause for concern.

Catch Distribution

In most years, the sport fishery in the Strait of Georgia is the largest single harvester of all Strait of Georgia hatchery stocks. However, it appears that the more northerly the hatchery location in Georgia Strait, the greater the catch in the Johnstone Strait net fishery and the south central B.C. and northwest Vancouver Island troll fisheries. In contrast to this, Capilano and Chilliwack, the two most southerly stocks, are caught in greater proportion in the Juan de Fuca net and the Southwest Vancouver Island troll fisheries.

Catch Per Unit Effort (CPUE)

Georgia Strait troll coho CPUE does not generally show a steady decline through the season. Instead, CPUE's typically increased or were stable during the initial weeks of the fishery, declined rapidly during mid-summer, and often increased in the closing weeks of fishing. Peak CPUE's (Fig. 8.4) and the in-season rate of decline in CPUE's have increased in recent years.

8.3 DISCUSSION

An examination of the historical escapement record indicates a significant decline for both Strait of Georgia and Fraser River stocks since the 1950s. This decline is accentuated when escapements to hatchery streams are subtracted from the total escapement. What is unclear at this time is the extent to which these apparent declines may be due to the uncertainty in the quality of escapement data available.

DFO field staff have observed that escapements to many east coast of Vancouver Island streams have declined precipitously in the last few years (R. Hurst, DFO, Nanaimo, pers. comm.). In response to this condition, enhancement measures are being undertaken to rebuild severely depressed mid-Vancouver Island stocks.

It is apparent that although we have seen an increase in the catch of coho salmon by the Georgia Strait troll and sport fisheries in the last three years, the overall trend in the total catch by all gear types, and especially the catch of wild fish has declined sharply since the 1950s.

This is a distressing signal since there is a perception, created by the three most recent years, that the coho resource in Strait of Georgia is very healthy. With the very restrictive measures which have been required to rebuild Strait of Georgia chinook stocks, it is evident that at least some of the effort which was formerly directed at chinook is now being redirected on coho. The potential impact of even more restrictive chinook conservation measures (which will be imposed in 1988) could be very serious.

Despite the uncertainties in the current estimates of coho directed effort, a dramatic increase in CPUE is evident in the last three years. Part of this increase may be due to increases in stock abundance, but peak CPUE's in 1986 were almost four times as high as those in 1980, even though the combined catch in the troll and sport fisheries was greater in 1980 than in 1986 catches. Within season rates of decline in CPUE appear to have increased beginning in 1985. The increase in both the CPUE and the rate of decline in CPUE suggests an increase in the intensity of the Strait of Georgia coho fishery as chinook fishing is restricted.

8.4 REVIEWERS' COMMENTS

Only one thorough review of this paper was received. This reviewer supported the analyses and recommendations but noted two data concerns he wished addressed. These were that the late-1970's sport catch should be reviewed because there are other estimates of the Strait of Georgia sport catches in this period which are lower than the estimates used in this paper; and that more emphasis should be directed to estimating the contribution of Puget Sound coho to fisheries in the Strait of Georgia. It was noted that most of the data concerns identified in the paper would likely lead to an under-estimation of the conservation need on these stocks. The reviewer further recommended that management actions be taken right away.

8.5 SUBCOMMITTEE ADVICE

Our preliminary examination of the available catch, escapement and coded wire tag data for Strait of Georgia coho stocks confirms the concerns expressed in the 1986 PSARC coho review. Exploitation rates appear to be much higher than those which can be sustained by wild coho stocks and catches are well below historic levels. These observations are even more alarming if the increasing trend in hatchery contributions is taken into account. The high initial CPUE's and the sharp rate of decline of CPUE during the Strait of Georgia troll fishery in recent years is an additional cause for concern.

In light of these observations the following actions are recommended:

1) A thorough review of all of the available data on Georgia Strait coho stocks is urgently required to confirm the status of the stocks and to determine the biological parameters which will produce maximum sustainable yield. Among other things, this will involve: a) verification of the historic escapement record, b) determination of the contribution of Strait of Georgia stocks to all fisheries, c) determination of the directed effort on coho by the Strait of Georgia troll fishery to calculate reliable CPUE statistics, and d) verification of hatchery exploitation rates (including hatchery escapement validation).

2) Escapement enumeration activities must be upgraded so that consistent indices of spawner abundance, useful for stock assessment purposes, are collected.

A key stream program should be established to monitor escapement, exploitation rate and ocean distribution from a representative sample of Strait of Georgia and Fraser River streams.

Priority should be given to those areas where we do not have hatchery information. Efforts should also be continued to verify the applicability of using hatchery coded wire tag releases to estimate wild stock parameters.

3) Predictive tools should be developed to enable forecasting of abundance and distribution in advance of a fishing season.

This would be essential if management regulations, aimed at restricting exploitation rates using catch ceilings, were to be implemented.

9. Stock Status and Assessment of Southern B.C. Chum Salmon and the 1988 Forecast (Working Paper S88-9):

9.1 INTRODUCTION

Southern British Columbia chum salmon are differentiated as two run groupings. Chum salmon returning to spawn in rivers draining into Johnstone Strait, the Strait of Georgia and the Fraser River are managed as a unit, often known as the Study Area or the inside run. The second run is composed of chum salmon returning to spawn in rivers along the west coast of Vancouver Island. The abundance of returning chum salmon in both runs has been augmented by production from spawning channels (Big and Little Qualicum) and other enhancement facilities.

9.2 STUDY AREA CHUM

The major commercial fishing areas for inside chum salmon are Johnstone Strait (Areas 12 and 13), mid-Vancouver Island (Area 14), and the Fraser River (Area 29). The Johnstone Strait fishery is a mixed-stock interception fishery with purse seiners accounting for about 75% of the total catch. The mid-Vancouver Island and Fraser River fisheries are more terminal and thus directed on specific stocks.

The estimated average annual total run size during 1955-1987 has been 1,906,000 fish, with a range of 451,000 fish in 1965 to 4,600,000 fish in 1973 (Fig. 9.1). Productivity of the run differs between odd- and even-numbered years particularly since the mid 1970s, with higher returns per spawner observed in even years. The mean age composition of the returns since 1958 has been 28.6% age 3, 65.9% age 4, and 5.5% age 5.

Escapement of the total run has been generally increasing since 1975 and particularly since the adoption of the clockwork management strategy (Hilborn and Luedke 1987) in 1984 (Fig. 9.1). The target escapement for the run is set at 2,500,000 fish, including at least 700,000 fish to the Fraser River. The target is largely based upon the judgement of people familiar with the spawning areas, and generally represents a view that this is the "optimum" number of spawning salmon based upon habitat availability. While the target of 2,500,000 fish is the long-term escapement goal, an interim goal of 2,000,000 fish has been set until 1990 under the clockwork management regime. Escapement throughout the area is largely measured by aerial and foot surveys, and a test fishery at Cottonwood at the Fraser River mouth provides an index of escapement. Mark-recapture estimation of escapement has been conducted in specific rivers in some years, but are not consistently conducted.

A prediction of run abundance for 1988 requires estimating the wild non-Fraser and Fraser River component, as well as the enhanced production from each group. Estimation of the wild non-Fraser component involves predicting survival rates of odd-year chum salmon broodyears by comparing with pink salmon survival rates; even-year chum forecasts use an average rate of return per spawner. Age composition required in the predictions of abundance is derived from the Johnstone Strait test fishery. Predictions of enhanced chum salmon abundance require estimates of numbers of fry released, applying SEP survival rate biostandards, and a fixed age of maturity (40% age 3, 60% age 4 for fed fry). Predicted returns in 1988 are:

wild non-Fraser	1,686,000
wild Fraser River	1,319,000
enhanced non-Fraser	512,000
enhanced Fraser River	546,000
TOTAL STUDY AREA RETURN	4,063,000

In the 1980s, the average error of predicted returns has been 22%, with the errors ranging from 2% to 36%.

9.3 WEST COAST VANCOUVER ISLAND CHUM

The abundance of chum salmon returning to the West Coast of Vancouver Island (WCVI) has been augmented by hatcheries at Nitinat and Conuma rivers. The major commercial fishing areas are in Area 21 (Nitinat) and Area 25 (Tlupana). These fisheries are largely terminal with enhanced production providing the majority of the catch. The combined WCVI catch increased from a mean of 489,000 in the 1950s to about 825,000 in the 1980s (Fig. 9.2). Overall mean annual catch during 1984-87 was highest in Area 21 at 81% of the WCVI total catch, followed by Area 25 at 15%, and Area 26 at 3%. Age composition of the returns average 26% age 3, 68% age 4, and 6% age 5.

Escapement of the total WCVI chum run has been variable, and since 1975 with no real trend in abundance. The target escapement for the entire run is 925,000 fish, with individual targets of 200, 150, 100, 195, 180, and 100 thousand fish for Areas 22-27 inclusive, respectively. Escapement targets for the WCVI run have been based upon the judgement of people familiar with the spawning areas and are generally considered as an estimate of stream spawning capacity. Escapement is determined through aerial and foot surveys.

As with the inside run, prediction of the returns for 1988 require estimation of abundance for both a wild and enhanced component. The enhanced component is predicted from the numbers of partly fed or fed fry released, an assumed survival rate of 1.2% for partly fed fry and 1.7% for fed fry, and a maturity schedule of 40% age 3 and 60% age 4. Predicted returns in 1988 are 690,000 enhanced chum salmon. The wild returns are estimated by applying a mean observed return/spawner by age class by statistical area to the appropriate escapements in 1983, 1984, and 1985. Total wild returns are predicted at 1,425,000 fish. The combined predicted returns in 1988 for WCVI wild and enhanced chum salmon is 2,115,000 fish. Variances of the mean observed rate of return/spawner are high, and thus the accuracy of the wild return prediction is likely low.

9.4 REVIEWERS' COMMENTS

This paper provided a good overview of the stocks, fisheries, and in-season management procedures but was criticized for not presenting a more detailed assessment of the stock productivities and status. In particular the use of total catch across all stock components did not allow evaluation of wild and enhanced contributions, and examination of returns per spawner over the range of spawning numbers observed was not presented. Examination of recruits per spawner versus spawners (conducted by one reviewer) shows a very scattered data set and a zero slope to the relationship. This reviewer felt that a critical evaluation of the assessment data was essential, particularly the accuracy of the escapement to wild stocks. Accurate escapement data is likely more necessary for chum since exploitation rates are low. Errors in escapement data could easily mask any relationship in recruits per spawner when escapements contribute 50% of the total return.

Future assessments should lessen the emphasis on in-season management processes and strengthen assessments of wild versus enhanced productions, and assessments of data reliability.

9.5 SUBCOMMITTEE ADVICE

Chum salmon production in southern B.C. has been increasing recently through enhancement and increased escapements to natural stocks. However the status of the natural stocks is unknown because of the uncertainty in the escapement data and the need to account for contributions to catch and escapement from enhanced stock. Determination of an optimal escapement for chum salmon may require more stock-specific means for stock identification and a key or indicator stream approach to escapement monitoring. The following should be undertaken now:

1) The escapement data should be examined very critically and badly biased data should be eliminated from stock and recruitment analyses. This may reduce the variation in returns/spawner and provide a more reliable estimate of optimum escapement.

2) Accuracy and consistency of escapement estimation must be improved particularly if run reconstruction methodologies are used to determine total returns from a stock.

3) Future assessment must more thoroughly examine production from natural and enhanced stocks and the interactions of these stocks, including the contribution of enhanced stocks to natural spawning populations.

4) The accuracy of forecasting the expected abundance of returning wild and enhanced chum salmon could be improved, perhaps by incorporating environmental variables, and by incorporating brood strength information already observed (i.e. sibling models should be examined).

10. Stock Status and 1988 Forecast of Cumshewa Inlet and Bella Coola Chum Salmon (Working Paper S88-10):

10.1 CUMSHEWA INLET (Area 2E) CHUM

Fall chum salmon returning to Cumshewa Inlet, Queen Charlotte Islands contain stocks bound for Pallant, Mathers, Chadsey and Carmichael Creeks. The Cumshewa Inlet fishery is a terminal fishery which intercepts very few passing stocks. The fishery is driven by the abundance of chum salmon dominated by the enhanced Pallant Creek stock.

During the 1970s chum salmon catches in Cumshewa Inlet were less than 5,000 fish annually and during this period were a small fraction of the total Area 2E chum catches (Fig. 10.1). The Pallant Creek hatchery was constructed in 1978 and reached full capacity in 1984. Mathers Creeks chum salmon are also enhanced at the Pallant Creek hatchery. From 1984 to 1987 the chum salmon fisheries in the inlet have harvested 47,742; 85,194; 28,610 and 86,577 fish, respectively. Escapements in the 1980s have been generally increasing in Area 2E (Fig. 10.1).

The total target escapement for Cumshewa Inlet is 56,000 fish, comprising 30,000 fish for Pallant Creek, 20,000 fish for Mathers Creek, 5,000 fish for Chadsey Creek, and 1,000 fish for Carmichael Creek. These escapement targets are generally considered as an estimate of stream spawning capacity and are based upon the judgement of people familiar with the spawning area.

Preseason expectations of both wild and enhanced chum salmon returning to Cumshewa Inlet are determined. Chum salmon escapement is collected from fence counts on Pallant and Mathers creeks and from visual counts on the other streams. The rate of return per spawner for Area 2E from 1960 to 1980 has ranged from 0.24 to 4.4. An average rate of return per spawner of 2.09 was used to calculate the 1988 expected abundance for Cumshewa Inlet. However, a rate of return of 1.5 was used for the 1984 brood year because of low egg to fry survivals in that year. A fixed age composition of 15% age 3, 75% age 4, and 10% age 5 is assumed for both wild and hatchery predictions. A fry to adult survival rate of 1.9% for fed fry and 0.9% for for unfed fry is assumed. The predicted return of enhanced and wild chum salmon in 1988 is determined from the number of fry released, the survival rate, and age at maturity. This results in a prediction of 228,000 enhanced and wild chum salmon returning to Cumshewa Inlet in 1988 and 285,000 chum salmon returning in 1989. A comparison of actual run size to predicted run size indicated that in 3 of 4 years the forecasted run size has been lower than the actual run size.

10.2 BELLA COOLA CHUM

In the central coast, summer chum salmon returning to Area 8 contain stocks bound for the Bella Coola and Kimsquit Rivers and six streams in the outer portion of Dean Channel (these have been amalgamated to form the Dean Closed stock).

Summer chum salmon and pink salmon in Area 8 have similar migration timing through the area, so many stocks of each species may be present along the migration route at any particular time. Fisheries conducted in Area 8 are thus interception fisheries, harvesting a mixture of stocks from both species.

Pink salmon are generally more productive in Area 8 than chum salmon. Pink salmon are thus the target species in the fishery. Summer chum salmon are harvested during pink salmon seine fisheries in Fitz Hugh Sound and Fisher Channel (outer portions of Statistical Area 8). A significant portion of the total Area 8 chum catch is taken in Dean Channel and Bella Coola gillnet only areas. Chum salmon destined for the Bella Coola and Kimsquit rivers can migrate up either or both Dean Channel and Burke Channel. It is unknown what proportion of each stock uses each channel. Dean Closed stocks migrate later than the other two stocks and are managed separately.

Catches have ranged from 49,000 fish in 1965 to 1,516,000 fish in 1986 (Fig. 10.2), accounting for 10 to 30% of the total British Columbia chum salmon catch. Production of summer chum salmon in Area 8 has been enhanced by hatchery propagation at Snootli Creek hatchery on the Bella Coola River since 1978. The Snootli hatchery is designed as a satellite hatchery, returning fry to their place of origin. Since pink salmon have a higher productivity rate than chum salmon, the intention of the Snootli Creek hatchery is to allow pink fisheries to continue at necessary exploitation rates without adversely affecting Bella Coola chum salmon stocks.

The target escapement for Area 8 chum salmon is 267,000 fish. This escapement target has been based upon the judgement of people familiar with the spawning areas and is generally considered as an estimate of stream spawning capacity. Escapement is determined through aerial and foot surveys.

Prediction of abundance of returning chum salmon requires escapement data and returns per spawner. The rate of return per spawner for Area 8 from 1967 to 1982 has ranged from 0.69 to 15.85. Because of a very wide range in the total return rates, the highest and lowest (1970 and 1982) were excluded from the average for total return rate and the age class return rates. The average return rate for age 3, 4, and 5 fish used to calculate the pre-season expectations for Area 8 were 0.57, 2.17 and 0.43, respectively. A fixed age composition of 20.37% age 3, 66.87% age 4 and 12.76% age 5 is assumed for the wild chum salmon predictions and a fixed age composition of 25% age 3, 70% age 4 and 5% age 5 is assumed for the hatchery chum salmon predictions. A fry to adult survival rate of 1.7% fed fry, 1.2% partially fed fry and 0.7% for unfed fry is assumed. The total abundance of wild and enhanced chum salmon returning in 1988 is predicted to be 536,000 fish and 650,000 fish in 1989. A comparison of actual run size to predicted runs size shows that in 3 of the 4 years the forecasted run size has been lower than the actual run size. The target escapements for Area 8 will remain fixed until sufficient data are available to assess this management strategy.

10.3 REVIEWERS' COMMENTS

Both reviewers noted that the paper did not assess the status of these stocks and queried how the escapement targets were to be evaluated.

Further, some recommendations did not follow from the text or needed more information in the text to support the recommendations. Future assessment work should address:

i) separating enhanced and wild production;
ii) improving forecast methods through accounting for variation in age at return and environmental conditions; and
iii) data problems so these weaknesses may be addressed.

10.4 SUBCOMMITTEE ADVICE

1) Increased accuracy in Area 8 pre-season forecasts is necessary, and inclusion of environmental factors into the forecasts may help in this regard. Sibling relationships should also be investigated.

2) Increased accuracy in determining stock composition of Area 8 chum catches is necessary in order to provide more accurate data on abundance of returning chum salmon. This would perhaps enable more accurate forecasts and an evaluation of current escapement targets.

3) Increasing sampling for age composition in Cumshewa Inlet catch and escapement is desirable.

4) Escapement enumeration in Area 8 should be improved to provide a more accurate index of spawner abundance.

11. Stock Status and Assessment of Fraser River Pink Salmon and the 1989 Forecast (Working Paper S88-21):

11.1 INTRODUCTION

Fraser River pink salmon were very abundant in the early 1900s with possibly as many as 28 million adults. After the Hells Gate rock slide of 1913, the stock declined considerably in size, but has since recovered to a recent maximum of 19 million pinks. Catches were high in the 1940s and 1950s but total run sizes were unknown. Consistent approaches to catch and escapement data have existed since 1959, one cycle after the International Pacific Salmon Fisheries Commission (IPSFC) began management of the stock in 1957. From 1959 to 1987 abundance has ranged from 1.9 to 18.9 million pinks (mean 9.1 million) and spawning escapement has ranged from 1.1 to 6.5 million (mean 2.5 million).

Pink salmon spawning occurs in the southern half of the Fraser River, mostly in October. The stock can be separated in some years into 'early' spawners (the majority) and 'late' spawners on the basis of earlier tag studies. The migration peaks of the two groups in the lower river are about 10 days apart. A minority of 'early' spawners pass through the Fraser Canyon destined for the Seton Creek/Bridge River on the Fraser or the Thompson River west of Kamloops Lake. However, pinks do spawn as far north as Quesnel and as far east as the tributaries to Shuswap Lake. Most of the smaller number of 'late' spawners move to the Harrison River and Chilliwack-Vedder rivers, tributary to the lower Fraser.

The only enhanced production of any consequence for Fraser pinks comes from the upper and lower Seton Creek spawning channels near Lillooet. The channels were built in the 1960s in mitigation for a hydro-electric project. Recent escapements to the channels have averaged about 26,000 fish or about 5% of the total escapement to the Seton area. However because of the much greater productivity of the channel spawners compared to the wild spawners, it is presumed that many of the approximately 500 thousand total spawners in the area are returns from the channel.

From 1959 to 1987 the total catch of Fraser pinks ranged from 740 thousand to 14.2 million (Table 11.1). Most of the catch was taken within the old IPSFC Convention Area which since 1985 is the Pacific Salmon Commission Fraser Panel Area (roughly between the 48° and 49°N parallels of latitude).

11.2 STOCK STATUS

From 1959 to 1977 Fraser River pink salmon escapements were in the range of one million to two million. A decision was made to increase this substantially and a record escapement of over six million was reached in 1985 (Table 11.2). The current escapement goal is six million. This target was determined by spawner-recruit analysis, but it will require more data from escapements of six million spawners or more before spawner-recruit relationships at this level can be calculated with much confidence. However, the stock is presently in a state of reduced abundance caused by poor egg-to-fry survival from the 1985 broodyear and by escapements in 1987 of approximately 1/2 of the escapement goal.

The escapement data for the Fraser River is considered to be good since enumeration methods have been thorough and consistent since 1957. The major spawning populations are enumerated with a Peterson disk mark-recapture method,and minor populations (<25,000) with a variety of "index" methods. Estimates of the total escapement are also derived by mark-recapture programs conducted in the lower Fraser River near Albion. Fecundity or the number of loose eggs per female before spawning is also estimated and pink fry production is regularly estimated at two locations in the Fraser.

11.3 FORECAST

The basis of the present forecasting method is the estimate of fry production made at Mission. The number is then used in a simple predictive equation based upon the result of correlations between past marine survival rates and environmental data in the summer of the juvenile year (Blackbourn 1985). The average error of the forecast was almost 29% during the return years 1979 to 1985, a period of increasing run size, and was similar for several cycles before that when total runs were much smaller. Some biological data from the fry caught at Mission has been utilized in the forecast method in some recent years. However, the factors accounting for the largest fraction of past variation in marine survival are (a) surface salinity from south-western Vancouver Island and (b) discharge of three rivers on the outer coast of Washington State, from June to September in both cases. Correlation coefficients with marine survival for brood years 1969 to 1983 were for salinity $r = 0.896$, $p<.01$, and for discharge $r = -0.918$, $p<.01$.

The 1989 forecast return of Fraser pinks will not be final before November 1988 at the earliest, since marine survival forecast information will not be available until then. The estimate of fry production from the 1987 spawning will not be available before June 1988.

11.4 DISCUSSION

This large and valuable stock of pinks is presently in a period of reduced abundance. However, the stock is very productive and can be rebuilt quickly with conservative management and improved monitoring. The following areas were commented on as needing attention:

1) Sub-stock fry production estimates.

2) Calibration of the total fry estimate at Mission.

3) Improved consistency of coastal salinity data for marine survival forecasts, and knowledge of the relationship between salinity at shore stations and that on the Continental Shelf.

4) Improved stock identification and abundance estimation from the early fisheries.

5) More data on the distribution and migration paths of Fraser pinks in northern B.C.

6) A method of identifying Fraser sub-stocks.

7) More accurate data on 'diversion' through Johnstone Strait.

8) More accurate in-season escapement data.

9) An estimate of the 'fall-back' of fish obstructed in the Fraser Canyon.

10) A check on the accuracy of the enumeration of escapement to the Main Fraser sub-stock.

11.5 REVIEWERS' COMMENTS

Both reviewers felt this paper accurately reflected the information available on Fraser River pink salmon. Three issues were identified:

i) the stock-recruitment analysis presented suggested that the optimal escapement could exceed 6 million spawners, why is the target escapement set at 6 million?
ii) more detailed documentation of the forecasting procedures should be included in future papers, and

iii) a need for improved passage of pink salmon through the Fraser Canyon before substantial increases in pink production is likely.

The inverse relationship between total run size and average body size of Fraser pink salmon was also noted. Consequently when large runs return the escapement target might be increased to account for the reduced fecundity of the smaller females.

11.6 SUBCOMMITTEE ADVICE

Maintaining escapements below the escapement target will prolong the period of reduced production from this stock. The Subcommittee recommends that escapements be increased to the goal as soon as practical. Further, escapements should be allowed to exceed the 6 million goal whenever feasible since evidence in this working paper indicates that the optimum exceeds this goal. Given the strong negative relationship between pink abundance and body size, managers should also evaluate expressing the escapement goal in terms of desired egg deposition; numbers of spawners would therefore vary with abundance.

The Subcommittee believes that further discussion between assessment, management, and enhancement staff is necessary before recommendations about which information needs to address can be provided. However, studies to evaluate the loss of reproductive potential from pink salmon being held back in the Fraser canyon should proceed.

12. Stock Status and Assessment of Study Area Pink Salmon in Southern British Columbia and the 1988 Forecast (Working Paper S88-8):

12.1 INTRODUCTION

The Study Area stocks include Upper Vancouver Island; Johnstone Strait; Kingcome Inlet; Bond to Knight Inlets; Loughborough to Bute Inlets; Toba Inlet, (Johnstone Strait group); Mid-Vancouver Island; Jerves Inlet; Howe Sound; Burrard Inlet, (Georgia Strait group). Odd year pink salmon are found in Johnstone and Georgia Straits while even year pink salmon are confined to Johnstone Strait and northern portions of the Strait of Georgia. The migration of the Johnstone Strait stocks is entirely via the northern approach (through Johnstone Strait) while Strait of Georgia stocks migrate via northern and southern (Juan de Fuca Strait) approaches.

The average estimated odd-year run size during 1959 - 1987 has been 1,788,000 with a range between of 350,000 and 3,738,000. Estimates of even-year run sizes during 1952-1986 averaged 2,400,000 with a range of 619,500 to 5,466,000. The majority of Study Area catch is taken in various mixed stock fisheries. This catch is allocated to stocks using methods of run reconstruction or genetic stock identification. In recent years returns of both odd and even-year pinks have declined, likely as a result of exploitation rates in the Johnstone Strait net fishery coupled with poor brood survival. The exception was 1986 and 1987 when a large component of returns were to hatchery facilities.

Results of previous studies (Vernon et al. 1964) indicate Study Area pink stocks, and Fraser River pink and sockeye runs have similar migration timing and migration routes, especially the more southern Study Area pink stocks. The Study Area stocks are generally less abundant when compared to Fraser River stocks and consequently are incidentally harvested. The timing of the Study Area pink salmon through Johnstone Strait extends from mid-July to the end of September, slightly earlier than Fraser pink stocks. Peak timing through Juan de Fuca Strait is approximately one week later than Johnstone Strait, however the component of Study Area pinks returning via this route is generally small.

Several Study Area pink stocks are currently being enhanced by habitat improvement and hatchery production. Major habitat improvements have included fishways on the Kakweiken and Embly rivers and side channel construction on the Phillips River. In addition, numerous stream improvement projects have been undertaken by community groups. Major enhancement facilities at Quinsam and Puntledge River have been operating since 1979. The Quinsam hatchery is the major producer with a 1987 egg target of 7.0 million. Wild Study Area pink returns are typically variable, the result of habitat degregation and the associated problems of water levels, water temperature, siltation and scouring (Anderson 1976).

12.2 STOCK STATUS (TABLES 1, 2; WORKING PAPER S88-8)

The average abundance of odd year pink stocks has been similar in recent years to historical averages (approximately 1.8 million). The average catches and escapement have been similar in the past and are in the order of approximately 850,000 and 950,000, respectively. For even year pink stocks the average return is substantially lower in recent years than historically, while escapements have remained relatively stable. The catches in recent years have declined due to reduced abundance.

Average production of Study Area Pink Salmon, 1956-1987.

Year	Catch	Escapement	Total Stock	Percent Exploit	Brood Escape	Brood R/E
Average Odd Year						
1959-1987	883,200	935,300	1,818,493	47.8%	977,820	2.58
1981-1987	837,900	1,033,700	1,871,500	42.7%	995,750	1.49
Average Even Year						
1952-1986	1,467,100	932,800	2,399,983	55.0%	892,934	2.97
1980-1986	548,500	931,300	1,479,775	34.6%	848,250	2.23

Trends between odd and even year returns have changed with the recent decrease of even year returns. The cause of this shift is not apparent. The exploitation rate of both even and odd years has declined over past years. This is a result of reduced fishing times in Johnstone Strait and terminal areas. Further, the amount contributed by stock to Study Area pink escapements appears to have shifted significantly. Recently (1980 to 1987) the Mainland Inlets, specifically Kingcome Inlet and Bond to Knight Inlet stocks, have comprised 75% (odd years) and 68% (even years) of the total escapement (detailed in Appendix A and B; Working Paper S88-8). Previously published optimum escapements suggest this figure should be approximately 30% and 40% for both odd and even years respectively. Escapements to other areas, including Upper Vancouver, Johnstone Strait, Loughborough to Bute Inlet, Toba Inlet, Jervis Inlet, Howe Sound and Burrard Inlet have been low. The one exception is Mid-Vancouver Island which recently (1986 and 1987) received substantial escapements, primarily returning to hatchery facilities.

Major enhancement effort has met with success in recent years. For specific systems (Kakweiken River) there have been up to a million returns recorded in some years. Hatchery production, most notably in the Mid-Vancouver Island region, has increased returns substantially.

Optimal escapements for each stream were established separately for odd and even years as the highest escapement that has produced an equal or greater escapement in the cycle year since 1951 (Anderson 1975). Currently optimal levels of escapements are being replaced by target levels that not only include the optimal number of fish the stream can support, but allow for limited harvesting opportunities and provide a greater probability of being achieved. These new target escapements are based on current stock rebuilding schedules, Fisheries officers experience of past stream utilization and a subjective assessment of potential harvesting.

The Study Area escapements by stock group since 1951 are listed in Table 2 of Paper S88-8. Escapement of odd year pink has averaged 935,000 between 1959 and 1987. Escapement of even year pink has averaged 933,000 between 1952 and 1987. Much of the escapement has occurred within Bond and Knight Inlet areas with the major contributing systems being Glendale and Kakweiken rivers. Study Area pink returns have fluctuated from year to year but no trend is obvious in the record of escapements, with the exception of depressed odd-year stocks from Toba Inlet south on the mainland. Factors which contribute to this variability include unstable environmental conditions during incubation and a restricted ability to directly control fishing pressure affecting these returns. Currently, Study Area pink stocks are being examined for further enhancement possibility, in addition current management strategies are being reviewed.

Escapements (in thousands) by cycle of Study Area Pink Salmon, 1951-87.

Odd-years (target esc.	51-59 Ave.	61-69 Ave.	71-79 Ave.	1981	1983	1985	1987
= 1798.9)	898.7	830.3	948.5	1111.4	1619.7	961.9	441.6
Even-years (target esc.	52-58 Ave.	60-68 Ave.	70-78 Ave.	1980	1982	1984	1986
= 1532.8)	707.1	873.1	1145.9	1383.4	573.7	387.5	1380.7

Study Area pink spawning populations are enumerated visually, either by foot, by air or by fence counts in the case of hatcheries. For the populations located in the northern portions of the Study Area (Areas 12 and 13) much of the escapement is enumerated visually by air, as the majority of streams are remote. For the southern areas, many of the streams are more readily accessible by land and much of the enumeration is performed visually by foot. The methodology for stream enumeration may vary from year to year as estimates are subjective and dependent on Fisheries staff.

12.3 FORECASTING

Preseason forecasting of wild pink returns for each major stock group is based on brood year escapements and the average productivity of each stock (return to escapement ratios). The average productivity is determined by comparing the total brood year escapement with subsequent return of total Study Area pink. The forecasting methodology is identical for odd and even cycle years. The cyclic average of this ratio and current year escapement are used as a basis to forecast the next year's cyclic returns. Included in the run forecast is an adjustment to the cyclic average productivity based on environmental conditions. The environmental conditions are a qualitative assessment of pre-spawning mortality and stream condition such as freezing, flooding or low water condition which affect egg to fry survival. This assessment is conducted by local area Fisheries staff and discussed with management biology staff to determine an adjustment factor which is then applied to the average productivity of each stock. The final adjusted productivity is then applied to the brood escapement to determine the forecasted return by stock group. The methodology and forecast of 3,210,730 for the 1988 return is present in Table 3 of Working Paper S88-8.

12.4 REVIEWERS' COMMENTS

A suggested stock identification program covering the West Coast of Vancouver Island troll fishery might improve stock recruitment analyses, and assist fisheries management. However the reviewers feel there are other more serious data gaps that have a higher priority. The escapement data are probably not accurate and since methodologies vary from year to year they may not even provide a reliable index of abundance. They certainly are not adequate for stock recruitment analyses, which is the method currently used for forecasting Study Area pink returns. The percent error on forecasts from 1970 to 1987 has averaged seventy-five percent and it is recommended that other forecasting methods be explored. The spawning ground enumeration procedure should be thoroughly reviewed, and even if no additional resources are available standardized methodology should be implemented and used annually.

The definitions of, and methodologies for determining target and optimum escapement goals are not well documented for the Study Area stocks, and require clarification.

12.5 SUBCOMMITTEE ADVICE

Even under passive management in Johnstone Strait some pink salmon stocks in the Study Area, particularly the enhanced stocks, will have harvestable surpluses in terminal areas. Assessment procedures and management plans should be developed to harvest these returns, particularly enhanced stocks in mainland inlets.

If the Region decides to develop and actively manage these pink salmon stocks then programs will be needed to identify migration timing, paths, and migration rates.

The use of run reconstruction procedures and the uncertainty in escapement goals requires that spawning ground enumeration procedures be reviewed. The use of run reconstruction requires that escapement surveys must be conducted consistently and in a standardized procedure.

SEP PRODUCTION

13. An Assessment of the 'Expo' Coho Production Experiment (Working Paper S88-12):

13.1 SUMMARY

Increased coho releases from B.C. hatcheries, timed for the World Fair Exposition held in Vancouver during the summer of 1986, did not provide the expected increase in catch relative to the catches observed in the previous year.

Comparison of releases and catch associated with six B.C. hatcheries, 1982 and 1983 brood years, catch estimated through the coded-wire tag program.

Brood year	Catch year	Total release	% increase	Total catch	% increase
1982	1985	5.133 M		378.7K	
1983	1986	10.186 M	+99%	396.5K	+4.7%

The reason catches did not increase in proportion to the increase in releases is that survivals at four of the six hatcheries involved in the experiment dropped substantially relative to the 1982 brood year, and because a higher portion of the stock moved outside the Strait of Georgia to areas of lower harvest rates.

Comparison of survivals to catch of six B.C. hatcheries, 1982 and 1983 brood years.

Hatchery	Brood year	Catch year	Number released	% increment	Survival to catch	% increment
Capilano	1982	1985	503,566		5.57%	
	1983	1986	1,282,044	+155%	3.68%	-34%
Chilliwack	1982	1985	544,679		11.48%	
	1983	1986	2,172,169	+299%	7.22%	-37%
Chehalis	1982	1985	389,205		8.72%	
	1983	1986	622,450	+60%	8.44%	-3%
Puntledge	1982	1985	1,269,181		11.31%	
	1983	1986	733,336	-42%	7.45%	-34%
Quinsam	1982	1985	1,174,047		5.13%	
	1983	1986	1,853,852	+58%	5.37%	+5%
Big Qualicum	1982	1985	1,252,569		4.03%	
	1983	1986	3,522,033	+181%	0.77%	-81%
Total	1982	1985	5,133,247		7.38%	
	1983	1986	10,185,884	+99%	4.51%	-39%

Overall, a relationship was observed between increasing hatchery production and decreasing survival. The relationship suggests that factors associated with the increased releases, including construction, handling, and crowding may be responsible for the decreased survivals. However, the data from Puntledge, Quinsam, and Chehalis hatchery confound this.

The marking of almost all coho with pelvic clips, excluding most coded-wire tagged groups, provided an opportunity to test the capacity of the coded-wire tag (CWT) program to estimate the catch of a large group of fish marked by an independent procedure. Approximately 88% of the total 1983 brood year release was marked by clipping either the left or right 'ventral' fin (more commonly referred to as pelvic fin). A sampling program which was designed to estimate the incidence of these ventral fin clips was conducted during the 1986 fisheries. The CWT estimate of ventral finclip catch underestimated the direct estimate of ventral finclip catch by 13% to 17%.

Comparison of catch estimates using coded-wire tag expansions and direct sampling for ventral finclips: 1986 catch year.

Fishery	Direct fin clip estimate ('000's)	CWT fin clip estimate ('000's)	% difference
Troll (1)	204	178	-13%
Net (2)	54	45	-17%
Strait of Georgia sport	141	121	-14%
Total	399	344	-14%

(1): Troll fisheries include South Central B.C., Northwest Vancouver Island, Southwest Vancouver Island, and Georgia Strait.

(2): Net fisheries include Johnstone Strait, Juan de Fuca Strait, Georgia Strait, and Fraser River.

At least two probable explanations for the shortfall of the CWT estimate relative to the direct ventral finclip estimate can be presented.

1) Shedding of the coded wire tags after release assessment. This assumes that there is not a high rate of naturally missing adipose fins (usually less than 0.1%). Missing wire tag rates at the hatchery rack often approach 15% to 20%.

2) Fin-clipped fish survived at a higher rate than coded-wire tagged fish. The assumption that marked fish are representative of unmarked fish is central to any marking experiment. Systematic biases such as this one often point to assumption violations.

There is evidence that some coded-wire tags are missed during recoveries from escapements to hatcheries. This was evident at the Chilliwack hatchery in 1986. This was determined because there are two estimates of the ratio of ventral fin clips to CWT adipose clips in the river:

a) from the hatchery, and
b) from a creel survey in the Chilliwack River immediately downstream from the hatchery.

(Because all the 1983 brood year releases from the Chilliwack hatchery were either ventral fin clipped or adipose clipped, the ratio of ventral fin clips to CWT adipose clips can be compared in both situations.) If the CWT/ventral fin clip ratio from the hatchery is used, there is a 40% shortfall in the estimation of the ventral fin clip escapement. If the same ratio from the creel survey is used, the shortfall in the escapement estimate disappears, indicating that it is likely that up to 40% of the coded wire tags were likely missed. Similar observations of discrepancies between the actual escapement of ventral fin clip coho and the CWT estimate of the escapement have been made at other hatcheries. However, this is the only instance where the discrepancy can be independently assessed.

13.2 REVIEWERS' COMMENTS

Both reviewers noted the unique opportunity to examine the coded-wire tag program through the use of an independent mark used on the Expo coho. However, the reviewers required clarification of methodologies before they could corroborate these analyses. The implication of these analyses is that the coded-wire tag program may under-estimate the catch of tagged groups of fish. This conclusion could have serious impact on chinook and coho assessments, and SEP Evaluations. Therefore, this analysis merits a more thorough review.

13.3 SUBCOMMITTEE ADVICE

1) Large scale marking experiments using marks which cause relatively little stress on the marked fish should be conducted to assess the effect of marking fish with coded-wire tags.

2) Hatchery racks should be routinely audited to ensure that data collection errors can be assessed.

3) The loss of coded-wire tags after application (pin shedding) should be more rigorously assessed. This should involve holding larger sub-samples of fish for longer periods of time than are presently used. In addition, these sub-samples should be as representative of the marked group as possible.

4) The Subcommittee recommends that the Salmon Assessment Program of the Biological Sciences Branch continue to evaluate the methodologies used in this working paper and to corroborate these important results.

14. Hatchery Production of Pink, Chum, Chinook, and Coho Salmon (Working Papers S88-11 and S88-16):

14.1 INTRODUCTION

The two reports presented assessed production from all chinook and coho hatcheries and from 13 major chum and pink hatcheries and spawning channels in British Columbia. Sockeye channels on the Babine and Fraser Rivers, and numerous small to medium sized chum and pink projects run by the Special Projects Division were not included in the reports.

Assessment is based on recoveries of marked salmon in the various fisheries and the escapement. Juvenile salmon released from enhancement facilities are marked with coded-wire tags (CWT) and adipose fin clips (AdCWT, chinook, coho, chum) or finclipped without CWT's (chum, pink). Statistical design, sampling programs, assumptions and sources of error are described in both reports. Key data for chinook and coho are readily available through the regional Mark Recovery Program (MRP) data base. Data for chum and pink stocks are compiled on microcomputer spreadsheets by Enhancement Operations but are less accessible than chinook and coho data.

14.2 DATA SOURCES AND QUALITY

Five statistics are needed for mark release-recovery analyses:
- number of marked juveniles released;
- number of unmarked juveniles released;
- incidence of marks in the fishery or escapement (fishery data is usually stratified over time, gear and space);
- identification of recovered marks; and
- total catch (by stratum) and escapement.

Juvenile mark and release data are provided by enhancement staff. Sources of MRP data for chinook and coho and comments on quality of data from these sources are summarized below. For chum and pink salmon recovery, sampling is done in terminal net fisheries on an opportunistic basis by MRP staff and in the escapement by enhancement staff. Catch of pink and chum in troll and non-terminal net fisheries is not sampled.

Sources of MRP data:

Component	Sampling for CWT incidence and recovery	Methods for total enumeration
Canadian commercial	20%	Sales slips
Strait of Georgia sport		Creel survey
- incidence	5%	
- recovery	Voluntary	
Other sport		Variable (not in MRP)
- incidence	0 to incomplete	
- recovery	Voluntary	
Indian Food Fishery	0	Variable (not in MRP)
United States	Similar to Canada	Statistics provided by U.S.
Escapement		Variable
- hard*	Variable to 100%	
- soft	(Inconsistent)	

*New "hard" data, e.g. keystream chinook not yet available. Hatcheries provided sampling guidelines annually.

Data quality and problems:

	CWT incidence and recovery		
Component	Quality	Problems	Enumeration
Canadian troll	Good	Reporting of catch from several statistical areas.	Catch reported to 1 area.
Canadian net	Good	Packers with mixed gillnet and seine catches.	Incidental catch of small fish by seines not totally accounted for.
Canadian sport			
- Strait of Georgia	Moderate	Awareness variable	Good
- Others	Poor	Awareness unknown	Inconsistent
Indian Food Fishery	Poor	No sampling	Inconsistent
United States	Moderate to good	Inadequate data to assess	Inadequate data to assess
Escapement	Variable	Little or no sampling of river spawners in many systems. Incomplete recovery of marks.	MRP includes hard data only

Overall, the most serious error sources by marking program are:

- unsampled and/or poorly enumerated components of catch and escapement for the coded-wire tag program, and
- unsampled fisheries and differential mortality of marked fish compared to unmarked fish for pink and chum salmon.

In general, the data for assessment of enhanced production are thought to be of good quality compared to data available for other fisheries management purposes in B.C. and elsewhere, but they do not account for all returns.

14.3 RESULTS AND DISCUSSIONS

Juvenile Releases

Table 14.1 summarizes releases for the reported facilities during brood years 1978 through 1985 and the proportion of the available rearing capacity used for 1985 brood fish. More extensive data are provided in the reports including numbers of fish at different stages when released (fry, fed fry, smolts), numbers by geographic areas or sites where released, and a wider range of brood year statistics.

Canadian Catch of Enhanced Stocks

Catch of enhanced chum, pink, chinook, and coho in Canadian fisheries is summarized by brood year in Table 14.2 and by recovery year in Table 14.3. Brood year catches include chinook and coho not associated with marked releases but the recovery year analysis does not. Estimated catch and percent SEP contribution by recovery year should be approximately 7% higher for chinook and 13% higher for coho to adjust for unmarked releases but the adjustment varies from year to year. It should be noted the chum and pink catch estimates are for only 13 facilities. No attempt is made in this report to account for other enhanced chum and pink production. Details on catch distribution are provided in the working papers.

In 1987, enhanced chum accounted for more than 37% of the B.C. catch, the highest proportion to date, although the catch of enhanced fish was more than twice as high in 1985 due to massive returns to Nitinat Hatchery. Contribution of enhanced pink salmon to the Johnstone Strait fisheries in 1987 was a record catch of 275,000 hatchery fish, accounting for almost 17% of the pink salmon harvested. Hatchery pink production comprises a higher proportion of the even year catches when there are no Fraser River stocks present. Hatchery chinook have comprised between 8.3 and 11.5% of the total B.C. catch since 1982, but numbers of fish harvested have declined during recent years. Hatchery coho catch doubled from 1978 to 1986 when 507,000 hatchery fish accounted for 9.3% of the total B.C. harvest.

Observed returns for the 1982 brood year are compared to forecasts based on SEP Biostandards and actual juvenile releases. Data for 1982 brood chum and chinook are incomplete (1987 five-year-old return data are not yet available). In addition, escapement data for chinook and coho are known to be substantially under-estimated.

1982 Brood Returns (Catch and Escapement)

Species	Forecast	Observed
Chum	1,708,000	2,300,000
Pink	47,000	72,000
Chinook	369,000	159,000
Coho	750,000	727,000

Survival of Enhanced Stocks

There is extensive discussion on the reliability of escapement data and the impact on estimated survival and exploitation rates in the working papers. Survival of enhanced fish (catch and escapement divided by release numbers) is examined in detail including time trends for each species, comparison of release strategies for chum and pink, and comparison of wild and hatchery coho smolt survival for stocks within the Strait of Georgia and Fraser River stocks. Survival of enhanced chum and pink salmon has shown a positive trend over time.

Percentage survival of enhanced pink and chum salmon (%'s are average over the 13 major facilities releasing pink and chum).

	Pink		Chum	
Broodyear	Unfed fry	Fed fry	Unfed fry	Fed fry
1978			0.65	0.91
1979	2.90	3.37	0.59	1.73
1980	0.76	1.98	0.18	0.67
1981	1.10	1.36	0.72	3.96
1982	2.28	3.52	1.16	2.05
1983	0.96	2.41	incomplete returns	
1984	6.08	14.86	"	"
1985	3.73	7.35	"	"

Survival of enhanced chinook and coho smolts has decreased over time (Fig. 14.1). However it is noteworthy, that survival of wild coho smolts from streams in inside waters of the Strait of Georgia and Johnstone Strait seem to have also decreased over the same time period (Fig. 14.2). Survivals of hatchery and wild coho seem to have been similar over this period.

14.4 CONCLUSION

In conclusion, enhancement in B.C. now accounts for a significant portion of Canadian chum, chinook and coho catch and of Johnstone Strait pink catch. Higher enhanced catches are anticipated as existing facilities reach capacity and new projects are developed.

Until data quality is improved, especially escapement, sport fishery and Indian food fishery data, statistics on the contribution, survival and exploitation rate of hatchery fish must be considered minimum values but the error associated with these statistics will vary between facilities.

14.5 REVIEWERS' COMMENTS

Reviewers of these documents noted the extensive data that was summarized and that the papers were very informative. The review of chinook and coho assessment provided an excellent overview of production and data limitations to the assessment. However, the authors should comment on what the likely impact of the various limitations would be on the assessments.

The review of chum and pink salmon production was one of the first thorough reviews undertaken on this topic. Both reviewers noted the extensive work required to present this working paper. One reviewer emphasized the numerous assumptions necessitated in this evaluation and recommended testing these assumptions if possible or presenting supporting references or evidence. He also noted that not all catches were included in the assessment and recommended that future assessments might concentrate on fewer facilities to reduce the data volume. The second reviewer recommended:

i) presenting the algorithms in the text to assist in evaluating the procedures;
ii) establishing a computer database for fin-clip data (the data is presently in spreadsheet software);
iii) exploratory analyses to develop predictive models using time-series analysis for fry-to-adult survival; and
iv) research on the mortality associated with fin-clipping since it is such a critical aspect of these assessments.

14.6 SUBCOMMITTEE ADVICE

1) Quality of mark release, recovery, and mark incidence data should be improved. Initial efforts in Canadian fisheries should be directed at the poorest quality data sources - outside sport fisheries and Indian food fisheries. Efforts should be made to increase sampling of hatchery fish escaping to natural spawning grounds and to verify mark incidence sampling in hatchery returns. New efforts should be directed to sources of the greatest error.

2) Quality of catch estimates should be improved for several fisheries. There are now only weak data for sport fisheries outside the Strait of Georgia, for freshwater fisheries, and for Indian food fisheries. Methods to improve troll catch records by statistical area should be improved. Studies to evaluate the net catch of juvenile salmon should be continued.

3) Escapement estimates to natural spawning areas of hatchery streams should be improved. This might require an indexing system. Studies to improve the accuracy of data previously cited in the working papers should continue.

4) Methods should be developed and implemented for mass marking hatchery juveniles in an economic and biologically feasible manner. Such methods would allow testing assumptions implicit in the mark recovery program.

5) Marking of wild coho stocks should continue, with emphasis on using stocks with a marking history and obtaining subsequent escapement data. Methods should be developed for marking wild chinook stocks.

6) Resources should be provided, or work load adjustments should be made, to ensure Stock Assessment staff responsible for reporting data in the MRP data base have the opportunity to verify accuracy of output reports.

7) Research programs should be initiated to investigate the survival trends of fish reared in hatcheries; particularly chinook salmon.

8) Future pink and chum salmon assessments should account for the constructive advice listed above from the second reviewer of the pink and chum working paper. Research concerning mortality associated with fin-clipping will be essential to improving reliability and accuracy of these evaluations.

METHODOLOGY

15. Status of Regional Capabilities for Coast-wide Stock Identification for Sockeye Salmon (PSARC Working Paper S88-7):

15.1 INTRODUCTION

Fishery managers require efficient techniques for stock identification to assess the productivity or regulate harvest rates on individual fish stocks exploited together with other stocks in "mixed-stock" fisheries. Recent advances in statistical methods and computational capabilities have made it possible to estimate the stock composition of mixed-stock fishery samples by examining biological attributes that differ among stocks. If satisfactory biological "markers" can be found, stock composition can be determined routinely without resorting to expensive and laborious tagging studies.

Fishery agencies in Canada and the USA are engaged in cooperative research on stock identification of sockeye salmon (Oncorhynchus nerka) under the auspices of the Pacific Salmon Commission. To date this research has focussed on evaluating the usefulness of four types of biological markers for estimating the composition of coast-wide mixtures of sockeye salmon stocks using Monte Carlo simulation techniques and baseline sampling data from 51 principal sockeye stocks in British Columbia and Southeast Alaska situated between the Fraser and the Taku rivers. Simulations were conducted to evaluate the relative accuracy and precision of stock composition estimates using a variety of these biological markers, either alone or in combination, including freshwater age, six scale pattern variables, the prevalence of the brain parasites Myxobolus neurobius, and five biochemical genetic (electrophoretic) traits.

15.2 RESULTS

The accuracy and precision of stock composition estimates almost always increased as additional markers were considered in the analyses. Also, accuracy and precision were always improved by reducing the complexity of the mixture problem by grouping similar stocks together using the allocate-sum procedure.

A general feature of the simulation results was that particular markers or combinations of markers served to distinguish some stocks very reliably but not others. Most if not all of the 51 stocks considered can be identified accurately enough for management purposes using all markers in combination under ideal conditions: 1) all baseline samples are representative, random samples, 2) genotype frequencies are in Hardy-Weinberg equilibrium, 3) scale pattern factors are normally distributed, and 4) mixture samples are relatively large (n=300).

15.3 DISCUSSION

These simulation results demonstrate that current techniques for sockeye stock identification can be very effective in particular applications. The usefulness of the techniques depends upon which stocks or stock-groupings are to be identified. Although it is impossible to evaluate all possible scenarios, the reliability of stock composition estimates for particular stocks can be inferred by noting their relative similarity to other stocks in a similarity dendrogram and by comparing this relative indicator of performance to absolute levels of performance determined through simulations.

A large number of markers used in combination is required to solve the complex coast-wide mixture problems discussed here. More precise results could be obtained in these simulations by omitting smaller coastal sockeye stocks from the analysis. Of course, this increase in precision would be obtained by sacrificing accuracy if in fact these small stocks occurred in significant numbers in the mixture samples. Depending on the purpose of the analysis, such _a priori_ assumptions may be worthwhile.

Scale pattern factors are complicated traits with great potential for discriminating among stocks owing to the large number of observable states for each factor. However, this can be a two-edged sword since it implies that larger sample sizes are required to correctly estimate the probability of observing each state in samples. A more serious problem with scale pattern data is that they reflect conditions for juvenile growth (e.g., population density and climate), and thus, may vary substantially from one year to the next (Wood et al. 1988). This implies that annual resampling programs are required to obtain representative samples. Moreover, reliable in-season estimates are not possible because stocks being caught in the fisheries have not yet segregated into their natal streams. Simulation studies are underway to determine how severely observed variations in scale patterns are likely to corrupt stock composition estimates based on samples collected in previous years.

Genetic markers and the prevalence of the brain parasite have proven to be remarkably stable from year to year (Wood et al. 1988). This attribute, combined with the simple statistical distribution of these markers, makes them ideal for use in complicated stock identification models where annual resampling of stocks in the baseline is prohibitively expensive. Unfortunately, too few genetic or stable parasite markers have been identified in sockeye salmon to achieve desired levels of stock resolution. Using only the genetic, brain parasite and freshwater age markers, which appear to be relatively stable over time, approximately 15 stock-groupings out of 51 stocks can be identified with acceptable accuracy and precision. Some of these stock-groupings are useful to managers. Others include stocks from various drainages and so are of limited usefulness to managers unless particular members of the group can be ruled out with additional knowledge about run timing or migration routes not available to the statistical model.

Two other genetic loci are polymorphic in sockeye -- alanine aminotransferase, _Alat_, and glyceraldehydephosphate dehydrogenase, _G1_-2 -- but the baseline sampling data for these loci remains incomplete. Also, the roundworm parasite Philonema oncorphynchi is present in some populations and not others and this distribution appears to be relatively stable over time. The latter parasite appears especially promising for identifying Fraser River and mainstem Stikine River stocks, but the practicality of field sampling for Philonema has yet to be evaluated. Hopefully, further research will reveal additional stable markers that will increase the potential for reliable in-season stock identification of sockeye salmon.

15.4 REVIEWERS' COMMENTS

The reviewers agreed with the procedures used and the stated utility of the tool for salmon management. Three fundamental questions were presented, however:

i) how are salmon "stocks" defined;
ii) how can we objectively evaluate whether it is worth trying to identify more biological markers; and
iii) is the conclusion that all 51 stocks can be resolved under ideal conditions justified or does it reflect a chance selection of atypical stocks in the simulations.

A more detailed examination of (iii) is being conducted but responses to the previous two items depend on the situation and/or question being addressed. In this analysis a salmon "stock" is assumed to be a separate spawning population. In general, however, salmon stocks do not cluster into geographic locations and the most accurate procedure to identify sockeye from a location is to resolve a mixture based on individual stocks and to then sum the contributions from clusters of similar stocks involving the geographic area of interest.

15.5 SUBCOMMITTEE ADVICE

Analyses being conducted to address item (iii) above should be completed and reported within 1988. Notable progress has been made in this area and research efforts should continue to focus on efficiently resolving sockeye stock identification issues, particularly identifying Fraser River sockeye coastwide.

Discussion must begin on where and by whom these techniques will be applied. Sample collection, processing, and analyses have exceeded the scope of research scale programs and routine interception monitoring seems essential for assessment and Salmon Treaty issues. The Region should seriously consider establishing a Regional Stock Identification laboratory and program. This would provide a focus for the expertise established and ensure consistent analyses.

16. Reconstruction of Harvest Rates and Stock Contribution in Gauntlet Salmon Fisheries: Application to B.C. and Washington Sockeye (Oncorhynchus nerka) (Working Paper S88-18):

16.1 SUMMARY

A method is presented which allows the assessment of catch by stock in all fisheries, the harvest (removal) rate by time period in each fishery and the proportion of each stock present in an area at any time period. Prior to the development of this method, there was no simple way to separate the catches of a mixed stock fishery into the contributions by each stock. Currently, even with the development of direct measurement techniques for stock separation (e.g. electrophoresis, parasite identification, scale analysis), there is still no other method available to estimate the total run and the harvest rate in a fishery. In the future, these two catch allocation methods could be combined to estimate parameters (such as diversion rates) which are currently impossible to estimate by objective methods.

The procedure described is best suited to net fisheries on migratory routes of salmon such as those currently used to harvest southern B.C. pink, sockeye, and chum stocks. The investigator is able to tailor the resolution of the assessment to correspond to the strengths and weaknesses of the available data. The data requirements are as follows:

1) escapement data by stock, separated into time periods;
2) catch data by fishery, also separated into time periods; and,
3) migration paths and speed by stock through each fishery.

The primary limitation to the method is that it requires large amounts of data, much of which may not be collected. This requires the investigator to make appropriate assumptions, some of which may introduce serious biases in the analysis. The paper discusses the importance and the effects of various types of assumptions and suggests procedures which might alleviate some of the problems.

The paper also proposes additional procedures that could be used to address the problems of differential vulnerability by stock in each time and area stratum. It also proposes a method by which confidence limits on the parameter estimates could be calculated.

An example using south coast sockeye stocks is provided to demonstrate the procedure.

16.2 REVIEWERS' COMMENTS

Both reviewers noted the importance of this procedure in salmon assessment and management, and that this paper is an important contribution to documenting the procedure. One reviewer recommended notation to clarify that presented in the paper. The second reviewer recommended that the procedure be published as soon as possible and that a second paper be prepared describing the computer algorithms and code.

16.3 SUBCOMMITTEE ADVICE

The Subcommittee recommends the preparation of a technical document on this methodology with documentation and computer code that can be implemented on IBM-compatible microcomputers; this procedure would serve as the Regional standard for run reconstruction so that multiple copies of the procedure and the resulting concerns about differences in the codes are avoided.

17. Description and Statistical Analysis of the Salmonid Mark-Recovery Database (Working Paper S88-20):

17.1 SUMMARY

Analysis of the CWT mark-recovery data is just beginning, since access to the data via computer is a necessary prerequisite to the design of the analysis itself. While B.C. currently has the most complete salmon mark-recovery database on the Pacific coast, even it is incomplete at the present time. As a first step in developing scientific understanding of these data, written documentation is produced covering the data within the database and the user access software. Producing this documentation is an enormous task which is compounded by the complexity of the data themselves. Nevertheless, the documentation is well underway and should be available within fiscal year 1988.89. In the meantime, Appendix A of the working paper provides a preliminary description.

In addition examination of the errors present in the current data has begun, focusing on estimating the relative bias between the observed returns to a hatchery and the CWT-estimated returns. Appendix B of the working paper describes a statistical model to estimate this relative bias and obtain the result that, on average, CWT returns underestimate observed hatchery returns by about 20%. Although the model has substantiated the presence of a bias, it cannot identify the cause using the data currently available. If this bias persists in the fishery, then Canada is substantially underestimating its hatchery contributions.

17.2 REVIEWERS' COMMENTS AND RECOMMENDATIONS

In general, this document is of high quality and the reviewers have no disagreement with its conclusions. The paper describes in detail efforts involved in trying to assess the data of the Coastwide Mark Recovery Programs. The descriptions of the data sets and data structure are concise and clear. The problems associated with the analysis of this data are also presented in a clear, accurate manner.

17.3 SUBCOMMITTEE ADVICE

It is recommended that a multiple marking experiment be performed to help identify the cause of the observed bias. Once the cause(s) has (have) been identified, the problem may be alleviated. It is planned to continue the case by case approach to the analysis of mark-recovery data, and it is anticipated that a judicious choice of problems will lead to methods useful to a wide number of users of the CWT data.

18. An Overview of Alternative Methods for Generating Preseason Forecasts of Pacific Salmon Returns (Working Paper S88-19):

18.1 SUMMARY

This paper provides a concise overview of alternative methods for generating preseason forecasts of Pacific salmon returns. In addition to traditional approaches such as Ricker stock-recruitment and regression models, various forecasting procedures that have proven useful in other resource modeling fields are discussed. In particular, classes of univariate and multivariate time series models are outlined. Numerous references are provided for each of the models presented.

A forecasting study was conducted to compare the ability of several models to produce accurate forecasts of sockeye salmon (Oncorhynchus nerka) returns to the Adams River. Most, but not all models produced forecasts that were at least as accurate as using the cycle means. A time series approach provided the best results with mean forecast errors being half those produced using the cycle means as forecasts and 30% less than employing the Ricker stock-recruitment model. Ad hoc combinations of the forecasts produced by individual models resulted in predictions that were comparable to the best time series model.

It is doubtful that the results of this single case study can be generalized to other salmon stocks in the Pacific region. More likely, appropriate forecasting models will have to be developed on a case by case basis. It is also important to note that the "best" forecasting model(s) will not necessarily be the same models employed to generate information such as optimal escapement levels.

18.2 REVIEWERS' COMMENTS AND RECOMMENDATIONS

The question of forecasting the return of salmon (as opposed to the response of recruitment to exploitation) has not received a great deal of attention in fisheries literature, despite the practical importance of the estimates to managers and users of the resource. Therefore, a review of the subject area applicable to salmon is a helpful contribution. The authors have been thorough in the presentation of candidate models commonly used in fisheries research and those that have proven useful in other fields. The reference list certainly provides the interested reader with the "critical mass" needed to pursue the subject in detail. The pick of Adams River sockeye for an initial exploration of model forecast ability is particularly appropriate, given the important role that the stock complex plays in the overall dynamics of the South Coast fishery. The review is certainly useful and, especially at the working level, long overdue.

18.3 SUBCOMMITTEE ADVICE

It is recommended that the utility of time series approaches for forecasting salmon returns, particularly those that incorporate biotic and/or abiotic factors, be investigated for other Pacific salmon stock. Where possible, the use of a split sample study should be encouraged in order to compare the performance of competing models. Further study is also necessary to determine if combinations of forecasts lead to improved estimates of salmon returns.

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Table 2.1. Forecast of abundance of 1988 Fraser sockeye return and net escapement goals.

Stock	4/2 Forecast	5/2 and 5/3 Forecast	Total adults	Net escapement[a] goal	Catches
Early Stuart	125,000	10,000	135,000	110,000	25,000
Bowron	45,000	5,000	50,000	22,000	28,000
Fennell	50,000	5,000	55,000	22,000	33,000
Pitt	30,000	30,000	60,000	24,000	36,000
Gates	90,000	0	90,000	36,000	54,000
Late Nadina	25,000	5,000	30,000	12,000	18,000
Early Chilko	250,000	50,000	300,000	120,000	180,000
Momich	30,000	0	30,000	12,000	18,000
Upper Adams	25,000	0	25,000	10,000	15,000
Seymour	25,000	10,000	25,000	14,000	21,000
Raft	35,000+	0	35,000	14,000	21,000
Late Stuart	15,000	0	15,000	6,000	9,000
Chilko River	750,000	100,000	850,000	374,000	476,000
Stellako	310,000+	40,000	350,000	80,000	270,000
Birkenhead	100,000+	135,000	235,000	80,000	155,000
Adams	25,000	10,000	35,000	7,000	28,000
Weaver	440,000	10,000	450,000	68,000	382,000
Harrison	15,000	0	15,000	3,000	12,000
Cultus	3,000	2,000	5,000	1,000	4,000
Portage	5,000	0	5,000	1,000	4,000
Miscellaneous[b]	30,000	5,000	35,000	14,000	21,000
Sub-total:	2,423,000	417,000	2,840,000	1,030,000	1,810,000
Other ages:			60,000	40,000	20,000
Grand Total:	2,423,000	417,000	2,900,000	1,070,000	1,830,000

[a] Escapment goals for individual stocks were approtioned on the Treaty defined level of 1 million for 1988 and relatively matched exploitation rates.

[b] Includes stocks such as Nahatlach, Big Silver and Widgeon, etc.

Table 11.1. Total commercial catch of Fraser River pink salmon in Canadian and United States fisheries.

Year	Canadian net	Canadian troll	Canadian total	U.S. total	Canadian and U.S. total
1959	2,955,585	258,752	3,214,337	2,150,023	5,364,360
1961	569,800	49,567	619,367	118,263	737,630
1963	2,132,432	144,429	2,276,861	1,210,802	3,487,663
1965	603,585	58,599	662,184	431,046	1,093,230
1967	5,769,585	1,282,932	7,052,517	4,035,185	11,087,702
1969	953,898	429,604	1,382,502	986,715	2,369,217
1971	4,841,061	769,620	5,610,681	2,315,087	7,925,768
1973	2,248,655	650,184	2,898,839	2,089,087	4,987,926
1975	1,796,309	517,726	2,314,035	1,158,246	3,472,281
1977	2,204,459	1,385,503	3,589,962	2,211,947	5,081,909
1979	4,282,000	2,272,000	6,554,000	3,956,000	10,510,000
1981	7,693,000	2,560,000	10,253,000	3,907,000	14,160,000
1983	6,699,000	1,892,000	8,591,000	1,765,000	10,356,000
1985	6,131,000	2,250,000	8,387,000	3,801,000	12,188,000
1987*	1,555,000	855,000	2,410,000	1,256,000	3,666,000

*Preliminary, may change following completion of racial analysis of catch samples.

Table 11.2. Fraser River pink salmon escapement.

Brood year year 1	Return year year 1+2	Early run pink salmon					Late run pink salmon			Total Fraser Escapement
		Canyon & misc.	Seaton Area	Main Fraser	Thompson Area	Total	Harrison Area	Chilliwack-Vedder	Total	
1957	1959	20,984	60,820	1,073,904	269,332	1,425,040	595,480	222,347	817,827	2,242,867
1959	1961	30,450	16,153	733,933	87,224	867,760	117,127	93,113	210,240	1,078,000
1961	1963	19,756	62,175	547,850	69,411	699,192	198,597	194,772	393,369	1,092,561
1963	1965	23,874	136,562	516,831	285,243	962,510	658,563	332,965	991,528	1,954,038
1965	1967	11,264	125,248	543,757	233,100	913,351	77,396	203,352	280,748	1,194,099
1967	1969	11,241	239,720	785,797	450,487	1,487,245	70,831	273,143	343,974	1,831,219
1969	1971	4,894	212,980	848,532	248,900	1,315,306	104,462	111,145	215,607	1,530,913
1971	1973	27,895	308,241	928,046	258,203	1,522,385	107,494	175,073	282,567	1,804,952
1973	1975	18,237	249,058	766,053	283,504	1,316,852	211,345	226,064	437,409	1,754,261
1975	1977	9,552	280,860	315,049	480,350	1,085,811	184,020	97,258	281,278	1,367,089
1977	1979	12,720	435,341	775,016	978,325	2,201,402	132,755	53,654	186,409	2,387,811
1979	1981	27,456	712,840	1,523,458	891,191	3,154,945	272,779	132,930	405,709	3,560,654
1981	1983	48,766	626,402	2,255,753	1,166,348	4,097,269	316,998	74,069	391,067	4,488,336
1983	1985	48,177	501,475	3,310,999	512,398	4,373,049	149,792	108,780	258,572	4,631,621
1985	1987	181,240	274,120	5,254,163	193,448	5,902,971	447,377	110,268	557,645	6,460,616
1987	1989	18,000	779,000	886,000	254,000	1,937,000	1,076,000	112,000	1,188,000	3,125,000

Table 14.1. Juvenile salmon released from all chinook and coho hatcheries and 13 major chum and pink facilities in B.C., 1978 - 1985 brood years (millions), and production capacity for the 1985 brood year.

Species	1978	1979	1980	1981	1982	1983	1984	1985	Capacity 1985	Releases as percent of capacity for 1985
Chum	48.3	70.2	94.0	109.2	147.2	158.7	146.8	158.7	182.5	87%
Pink	0	1.8	5.4	7.0	2.9	7.7	4.4	10.6	9.8	100%
Chinook	14.3	16.4	19.8	17.6	24.8	29.4	35.0	42.7	58.9	72%
Coho	4.7	8.7	7.7	12.2	17.7	22.7	25.2	21.4	24.3	88%

Table 14.2. Enhanced contribution to Canadian fisheries for all chinook and coho hatcheries and 13 major chum and pink facilities in B.C., by brood year.

	Brood year							
Species	1978	1979	1980	1981	1982	1983	1984	1985
Chum	178,000	177,000	135,000	1,965,000	1,355,000	N/A	N/A	N/A
Pink	0	41,000	23,000	42,000	52,000	55,000	260,000	275,000
Chinook	222,000	194,000	179,000	171,000	136,000	N/A	N/A	N/A
Coho	290,000	285,000	365,000	322,000	608,000	668,129	N/A	N/A

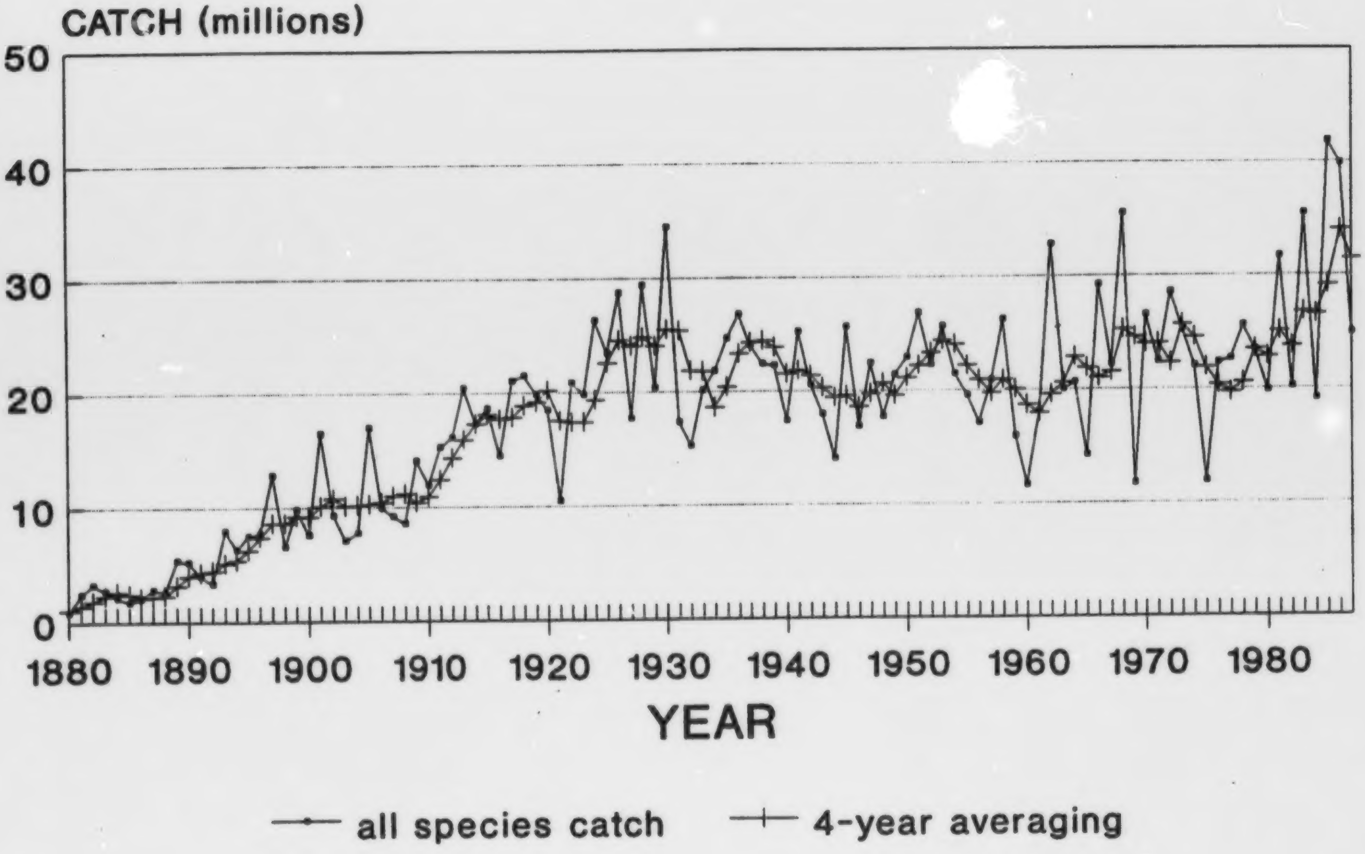
N/A: Not available.
Data include catch to 1986 for chum, chinook and coho and to 1987 for pink salmon. Figures shown for 1983 brood chum and chinook are incomplete.

Table 14.3. Enhanced contribution to Canadian fisheries for all chinook and coho hatcheries and 13 major chum and pink facilities in B.C. by catch year.

Species	Catch	Catch year									
		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Chum	Total B.C.	2,978,708	866,324	3,452,751	1,122,961	2,967,970	1,001,000	1,843,000	5,471,000	5,580,000	2,217,000
	Enhanced	287,060	6,201	103,642	47,192	228,686	127,962	398,461	1,936,171	1,270,816	830,124
	%Enhanced	9.6	0.7	3.0	4.2	7.7	12.8	21.6	35.4	22.8	37.4
Pink	Total A.12,13	-	-	-	292,443	182,714	7,517,694	215,700	5,363,229	500,786	1,638,742
	Enhanced A.12,13				40,501	22,949	41,921	51,760	55,117	259,779	274,986
	%Enhanced				13.9	12.6	0.6	24.0	1.0	51.9	16.8
Chinook	Total B.C.	1,835,668	1,767,700	1,623,869	1,386,355	1,397,042	1,147,986	1,378,993	1,104,369	994,412	N/A
	Enhanced	97,236	112,678	110,049	85,787	126,386	131,890	142,162	92,139	91,154	
	%Enhanced	5.3	6.4	6.8	6.2	9.1	11.5	10.3	8.3	9.2	
Coho	Total B.C.	4,436,636	4,322,012	4,056,408	3,206,177	3,596,541	4,526,952	4,042,736	3,673,631	5,474,890	N/A
	Enhanced	251,604	259,373	290,673	261,815	254.203	338,132	265,913	439,453	507,534	
	%Enhanced	5.7	6.0	7.2	8.2	7.1	7.5	6.6	12.0	9.3	

Notes: Pink catches are reported for Areas 12 and 13 since these are the only areas impacted by pink enhancement covered in the working papers. Chinook and coho catches are for mark associated groups only as described in the text. Chinook and coho total B.C. catch represents all commercial fisheries but only sport recoveries in the Strait of Georgia.

Figure 1.1 - Historical salmon catch in British Columbia (1880-1987)



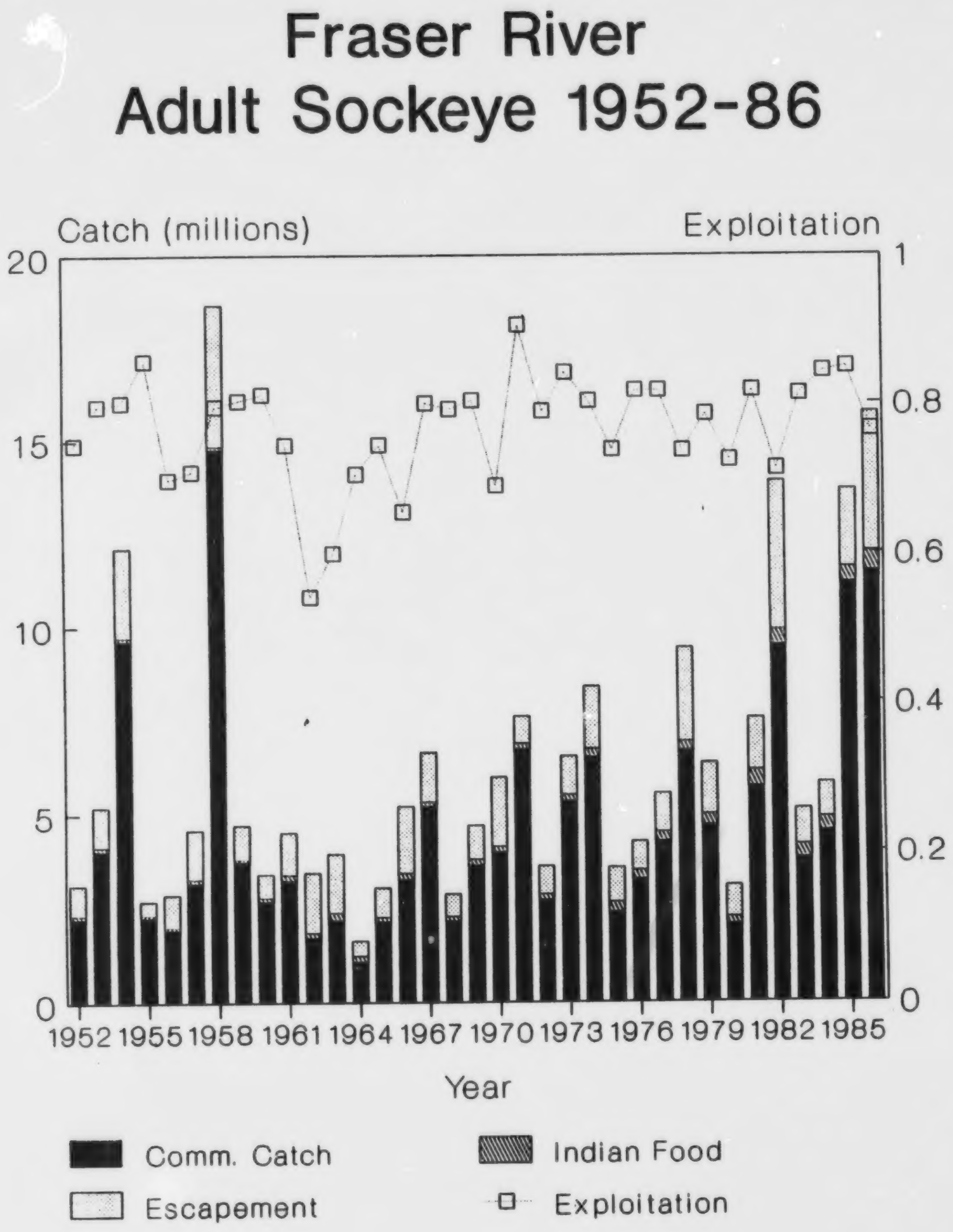
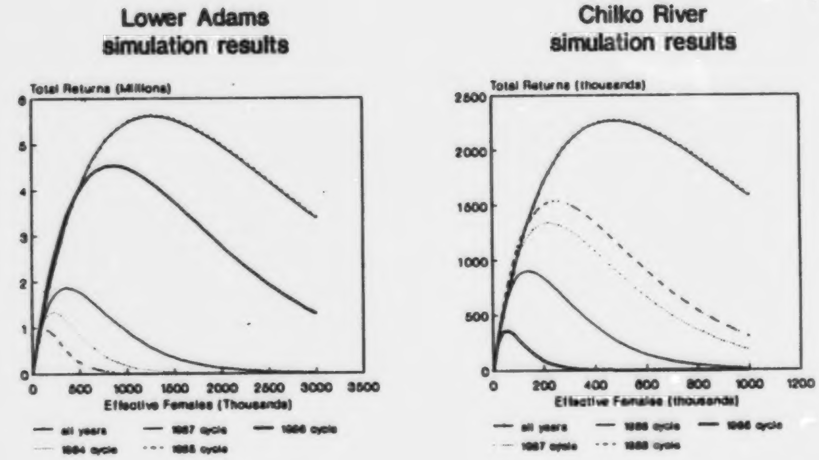


Figure 2.1. **Abundance trends of Fraser River sockeye, 1952-86.**


Lower Adams simulation results

Chilko River simulation results

Figure 2.2. Results from Monte Carlo simulations (n=1000) showing potential time-series bias when fitting Ricker models to cycle years data when the all-years assumption is true. Results show the bias causes the curves to bend at fractions of the "true" curve at levels consistent with curves fit to the observed historical spawner-recruit data.

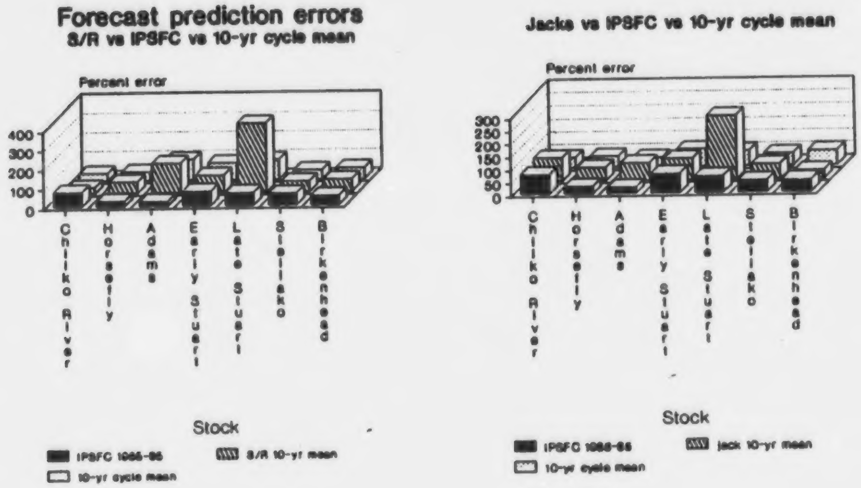


Figure 2.3. Forecasting errors for Fraser River sockeye comparing results from IPSFC methods with results using the Ricker model, brood year jack returns and the 10-yr cycle mean.

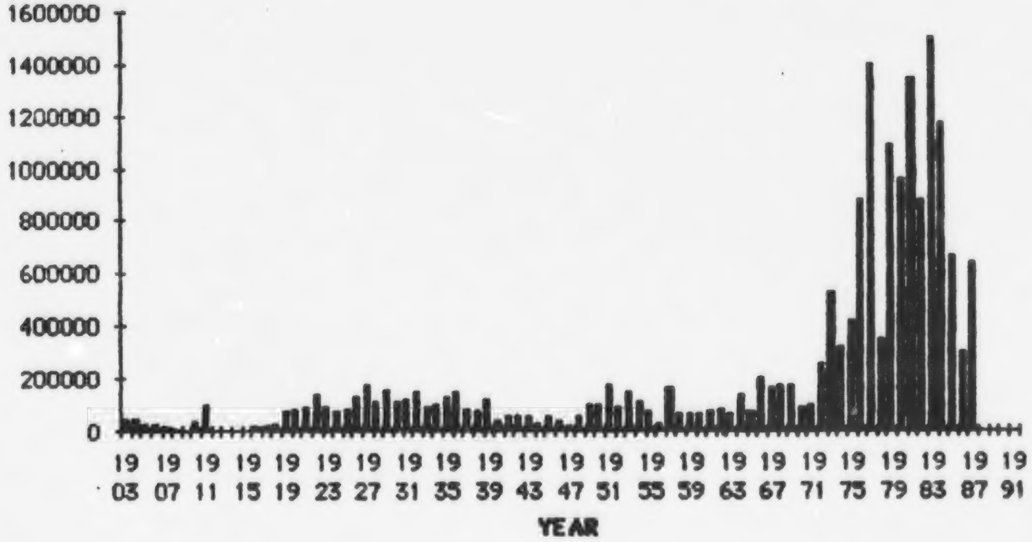


Figure 3.1 Unadjusted annual estimates of total returns of sockeye to Barkley Sound between 1903 and 1987. Observations include: catch estimates only from 1903-1917, total catch plus Henderson escapement only from 1917-1926, total catch plus Henderson and Great Central escapements from 1926-1949, total catch plus escapements to Henderson, Great Central and Sproat lakes from 1950-1987.

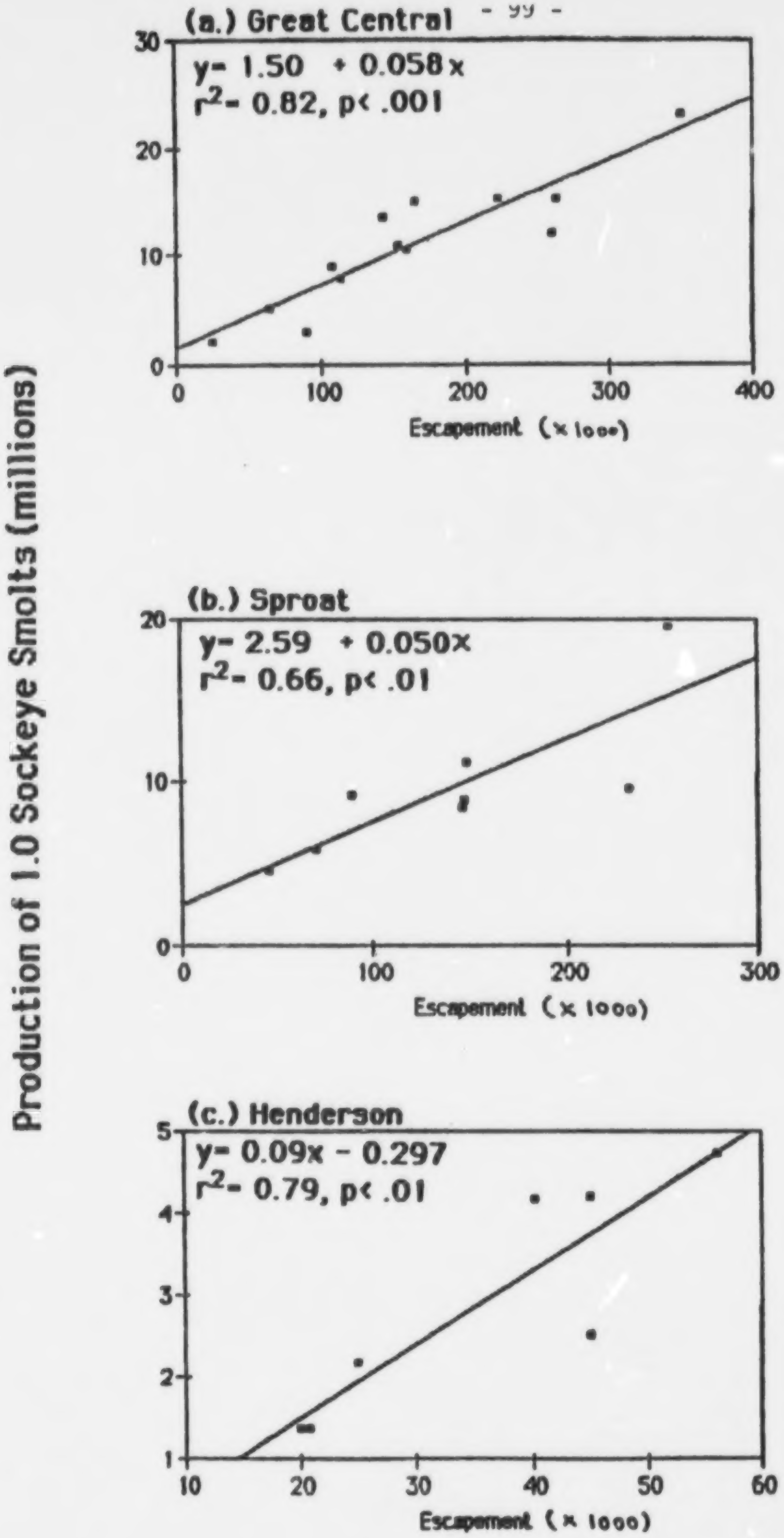
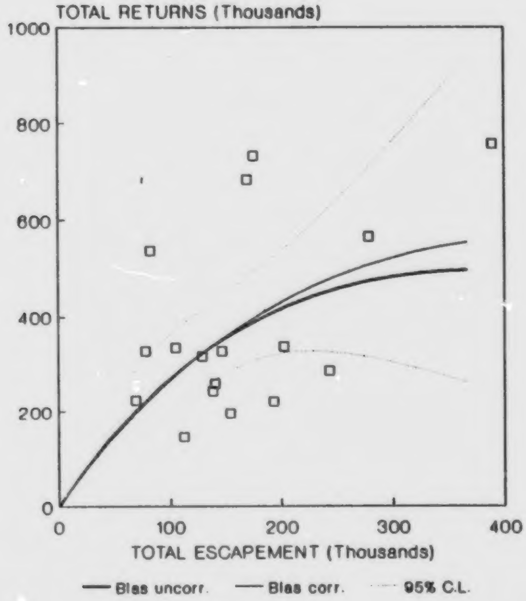


Figure 3.2 Relationships between sockeye escapements and yearling smolt production in (a.) Great Central, (b.) Sproat and (c.) Henderson lakes.

Figure 4.1. Nass River sockeye stock-recruit curves for brood years 1964-80. Catch, escapement and exploitation for return years 1969-84.

STOCK-RECRUIT CURVES



1964-80 brood years

CATCH, ESCAPEMENT AND EXPLOITATION

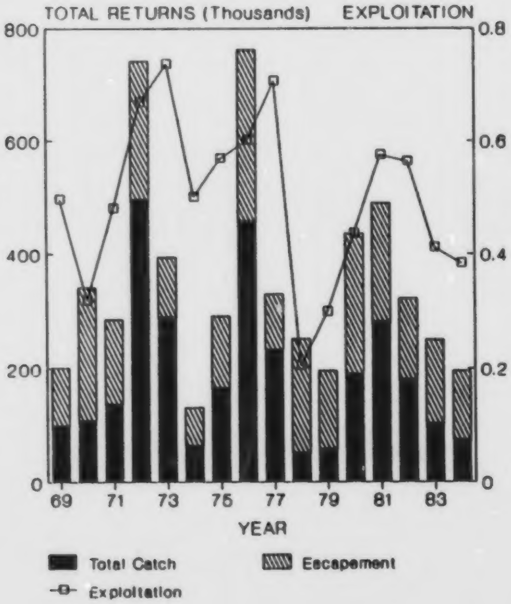
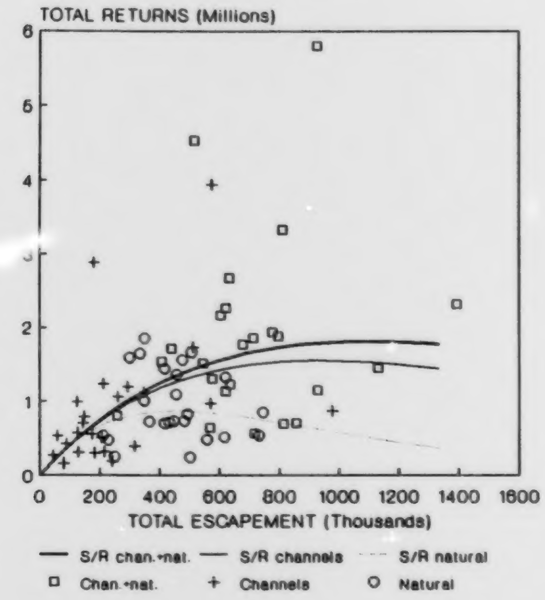


Figure 4.2. Skeena River sockeye stock-recruit curves for brood years 1958-81. Catch, escapement and exploitation for return years 1945-86.

STOCK-RECRUIT CURVES



1958-81 brood years

CATCH, ESCAPEMENT AND EXPLOITATION

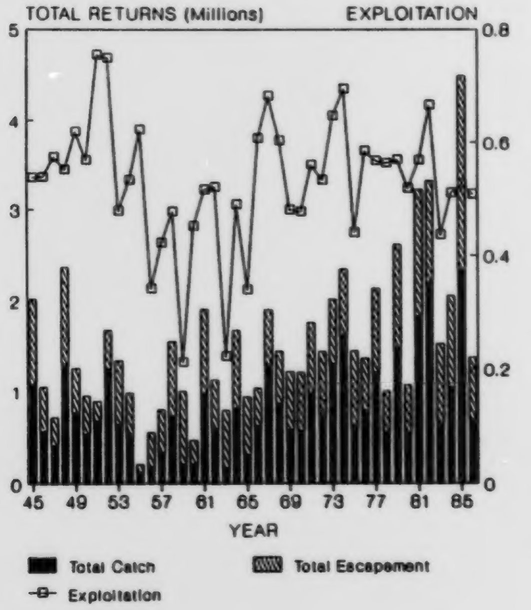


Fig. 5.1: Area 9 Sockeye Runs
Escapement and Total Stock, 1951-1987

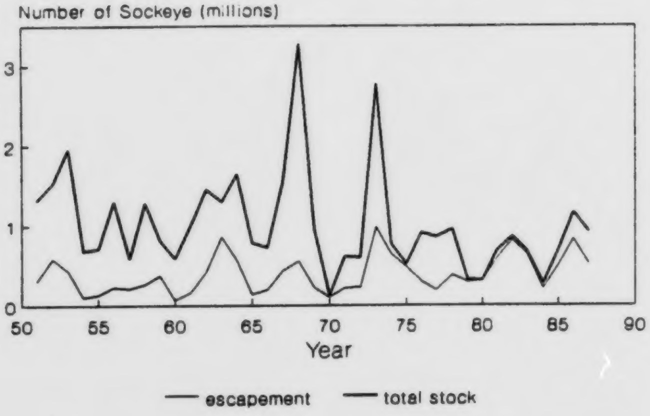


Fig. 5.2: Area 10 Sockeye Runs
Escapement and Total Stock, 1951-1987

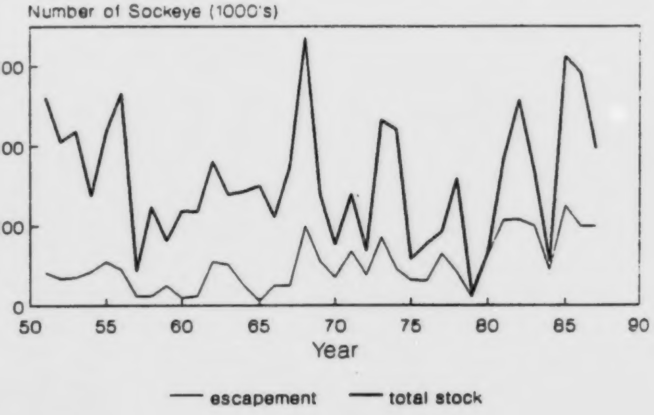


Fig. 5.3: Area 9 Sockeye Harvest Rates
1951-1987

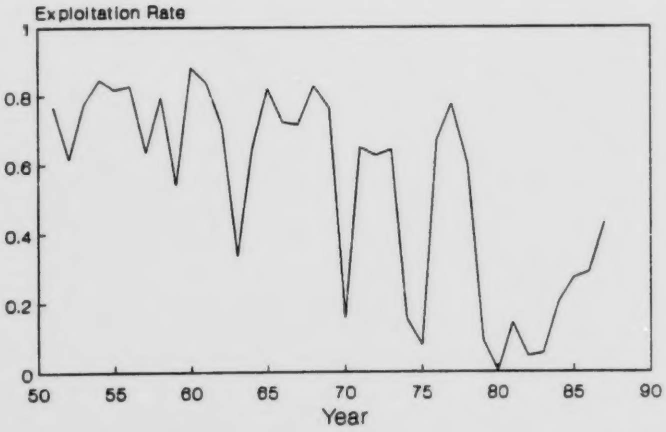


Fig. 5.4: Area 10 Sockeye Harvest Rates
1951-1987

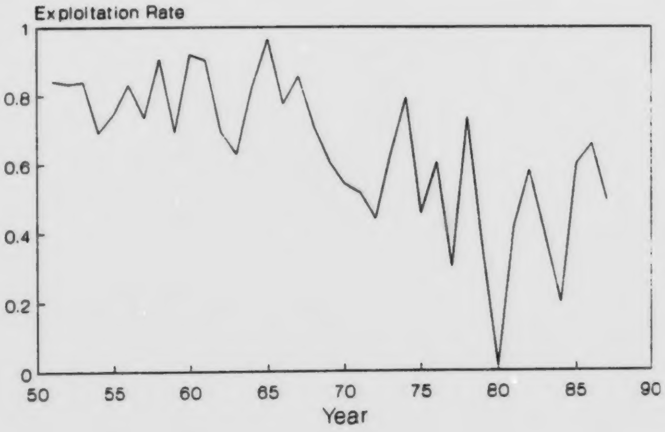


Fig. 5.5: Area 9 Sockeye Productivity Stock-Recruit Data, 1966-1981

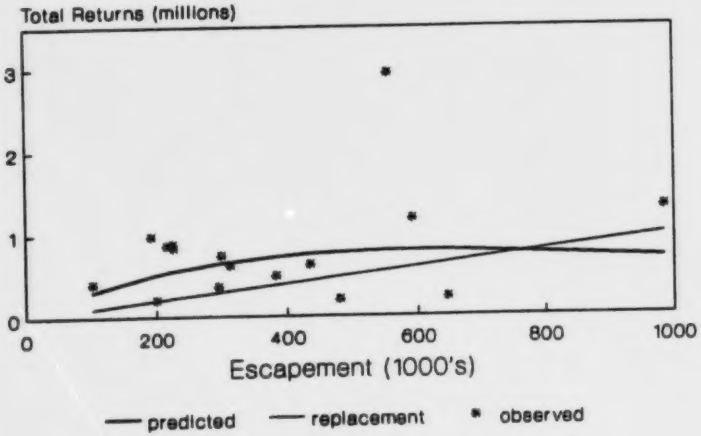


Fig. 5.6: Area 10 Sockeye Productivity Stock-Recruit Data, 1966-1981

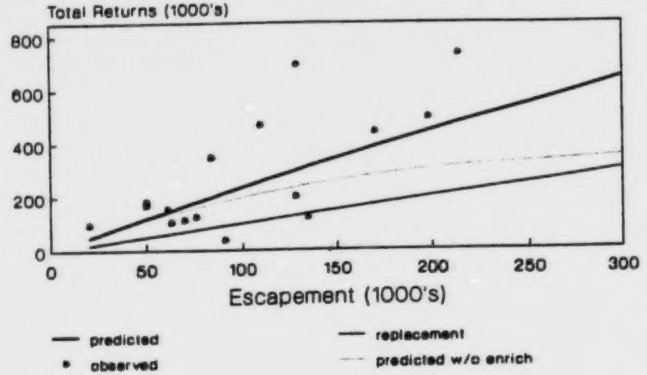
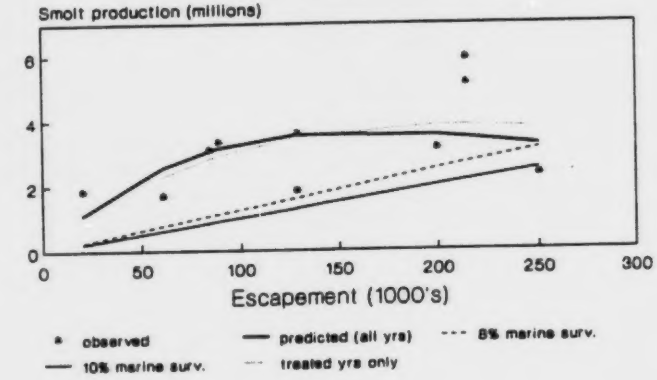


Fig. 5.7: Area 10 Smolt Production 1976-1985 brood years



Marine survival determines replacement

Fig 6.1 - Historical Catch & Escapement Numbers of Chinook

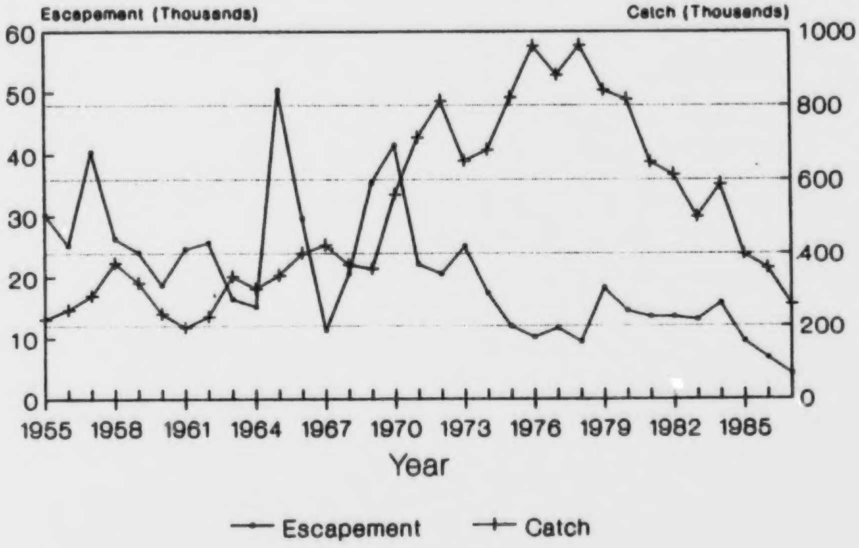
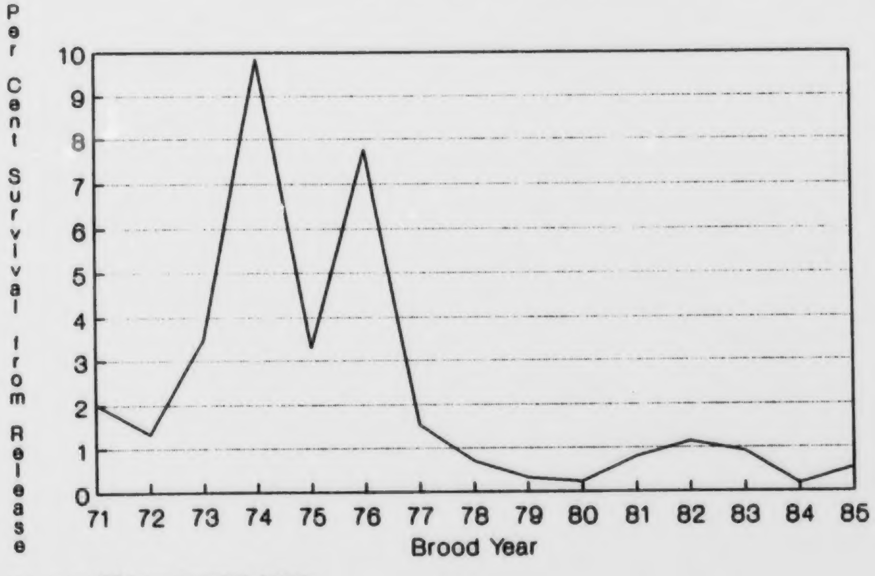


Fig 6.2 - BQR Chinook Survivals by Brood Year



Returns up to 1987 are included. Incomplete ages for 83 to 85 brood years are estimated (regression analysis).

Fig. 7.1 Early Run Skeena River Coho Total Catch

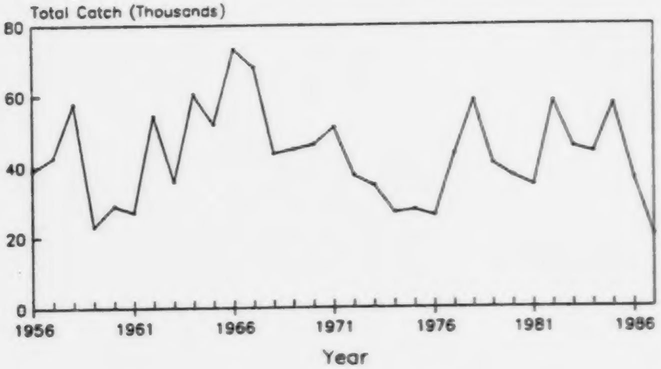
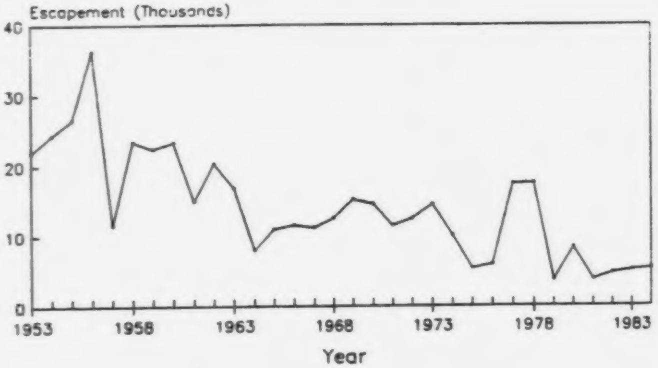


Fig. 7.2 Upper Skeena /Bulkley River Coho Escapements



Note:- From fishery officer estimates

Fig. 7.3 Skeena River Test Fishery Coho Index 1956 to 1987

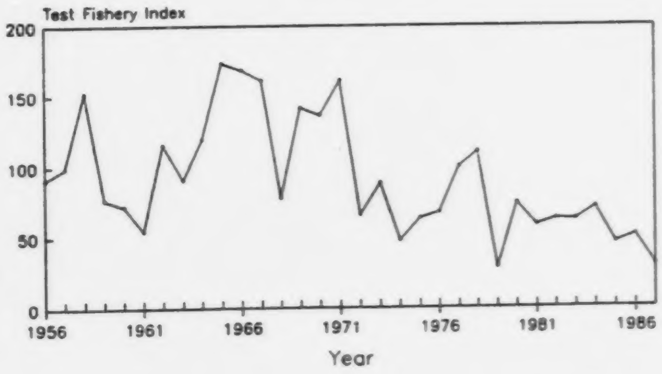


Fig. 7.4 Babine Fence Coho Count to Sept. 13th

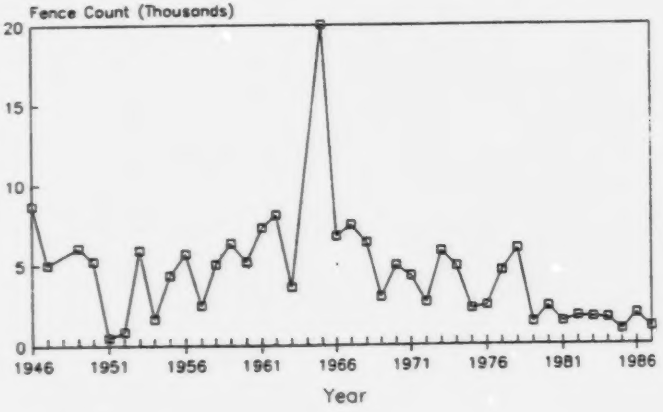
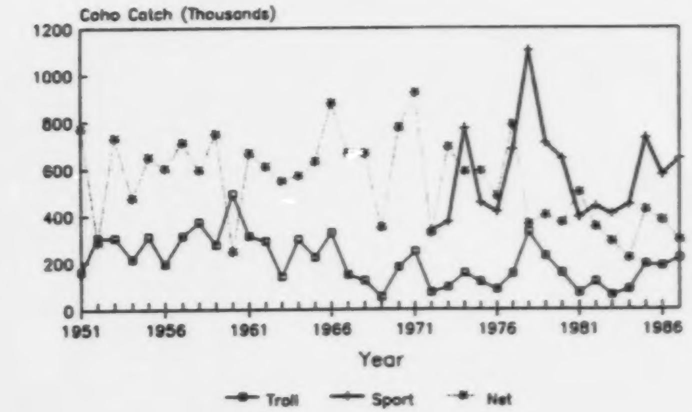
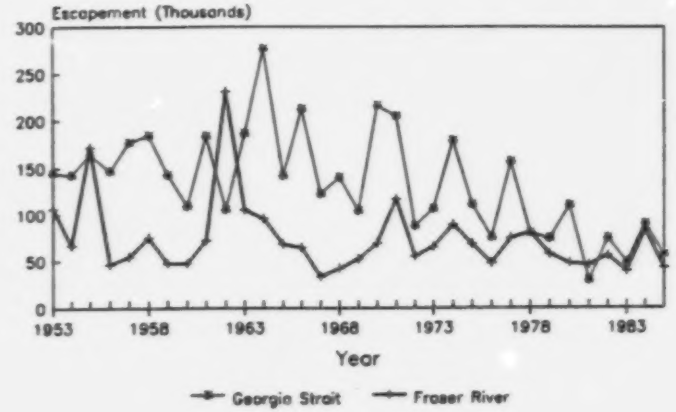


Fig. 8.1 Georgia Strait Troll, Sport and Net Catch of Coho, 1951 to 1987



Net catch includes Areas 11 to 20 and 29

Fig. 8.2 Georgia Strait and Fraser River Coho Escapements 1953 – 1985



Hatchery streams subtracted from Georgia Strait

Fig. 8.3 Big Qualicum River Hatchery Age 3 Exploitation Rate

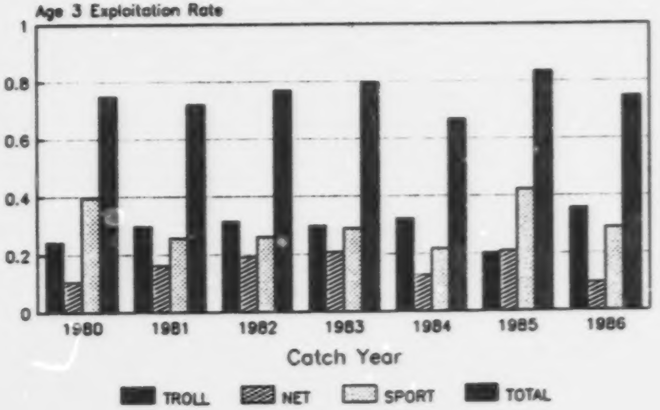
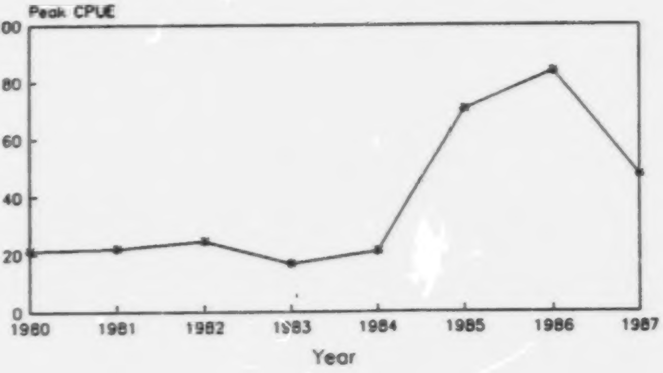


Fig. 8.4 Georgia Strait Troll Coho Peak Weekly Catch per Unit Effort



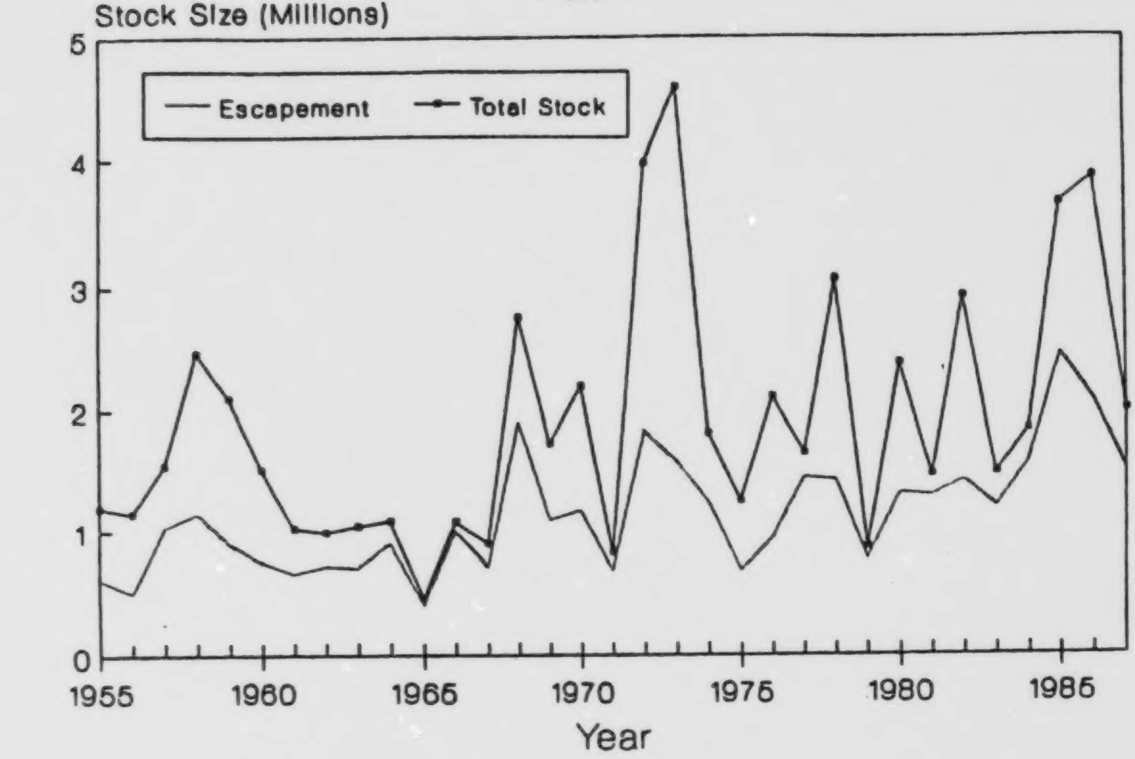


Fig. 9.1 Inside South Coast Chum Salmon Escapement and Total Stock 1955 to 1987.

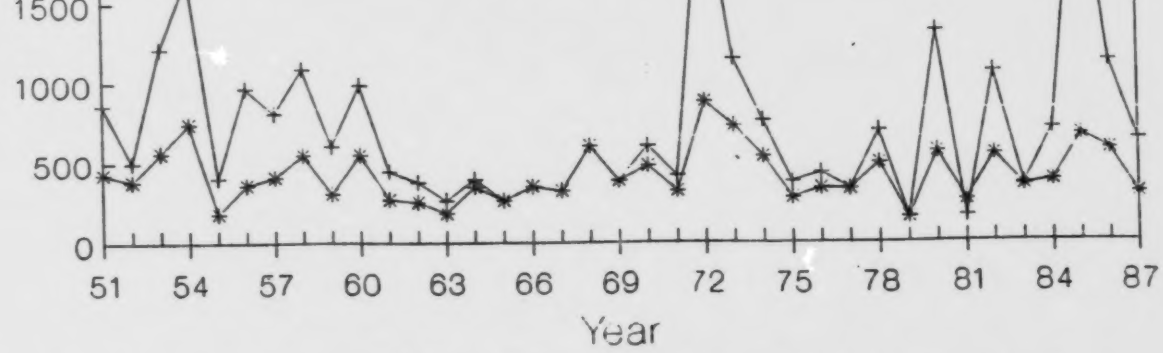


Fig. 9.2 West Coast Vancouver Island Chum Salmon Escapement and Total Stock 1951 to 1987.

Fig.10.1 Area 2E Chum Escapement and Total Stock
1951 to 1987

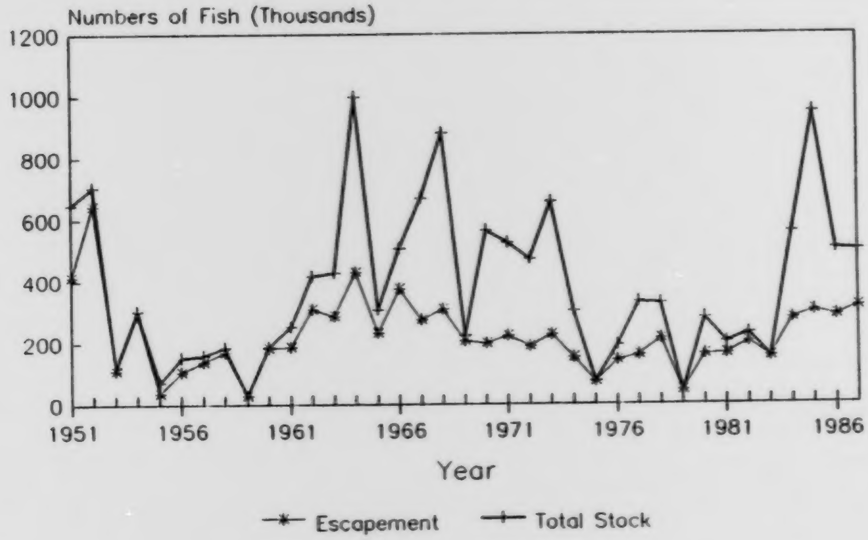
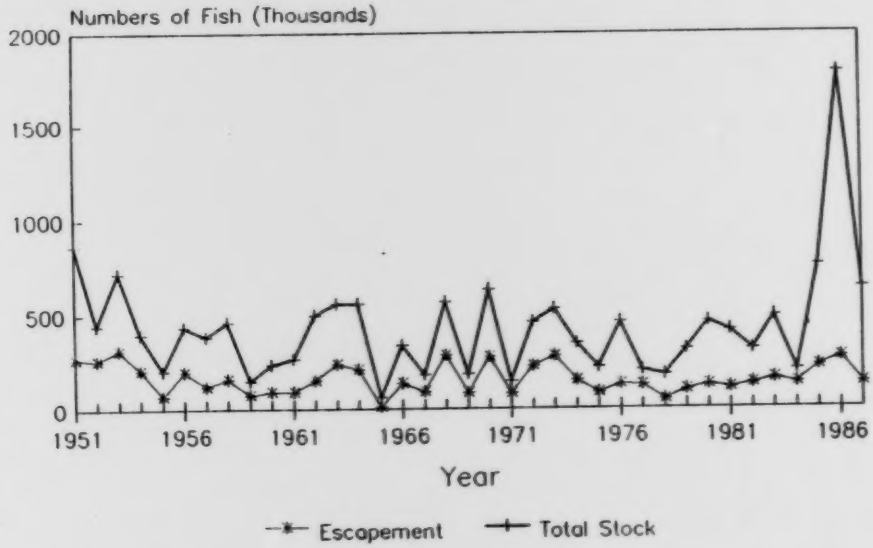


Fig. 10.2 Area 8 Chum Escapement and Total Stock
1951 to 1987



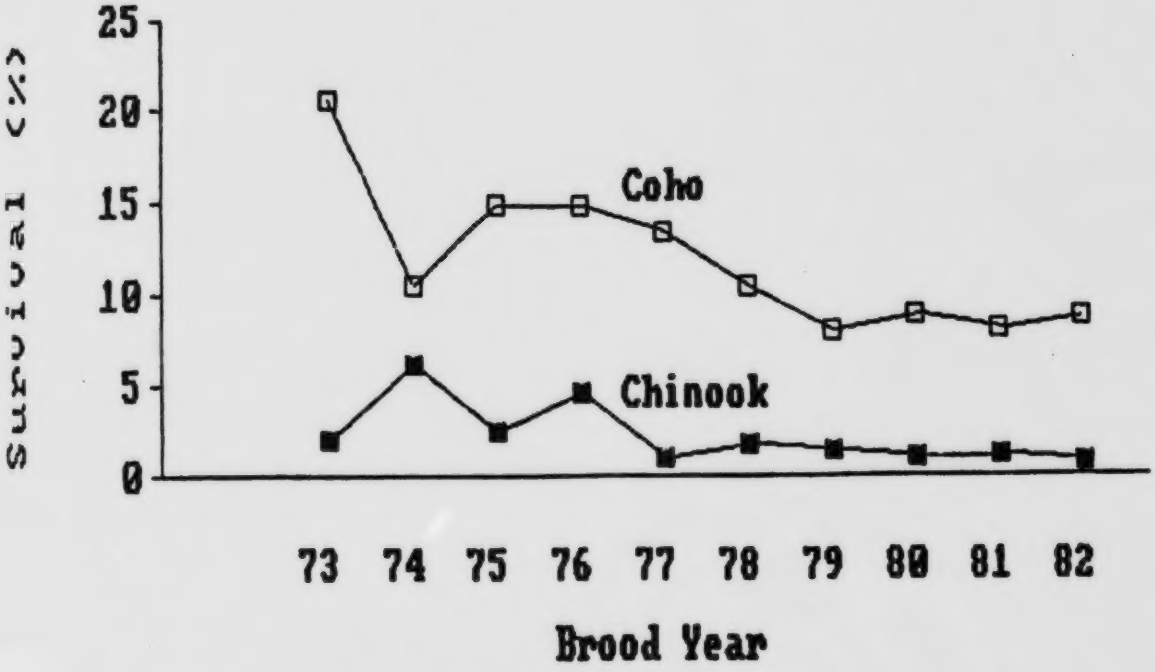


Figure 14.1 Survival of B.C. hatchery chinook and coho smolts by brood year 1973 - 1982.

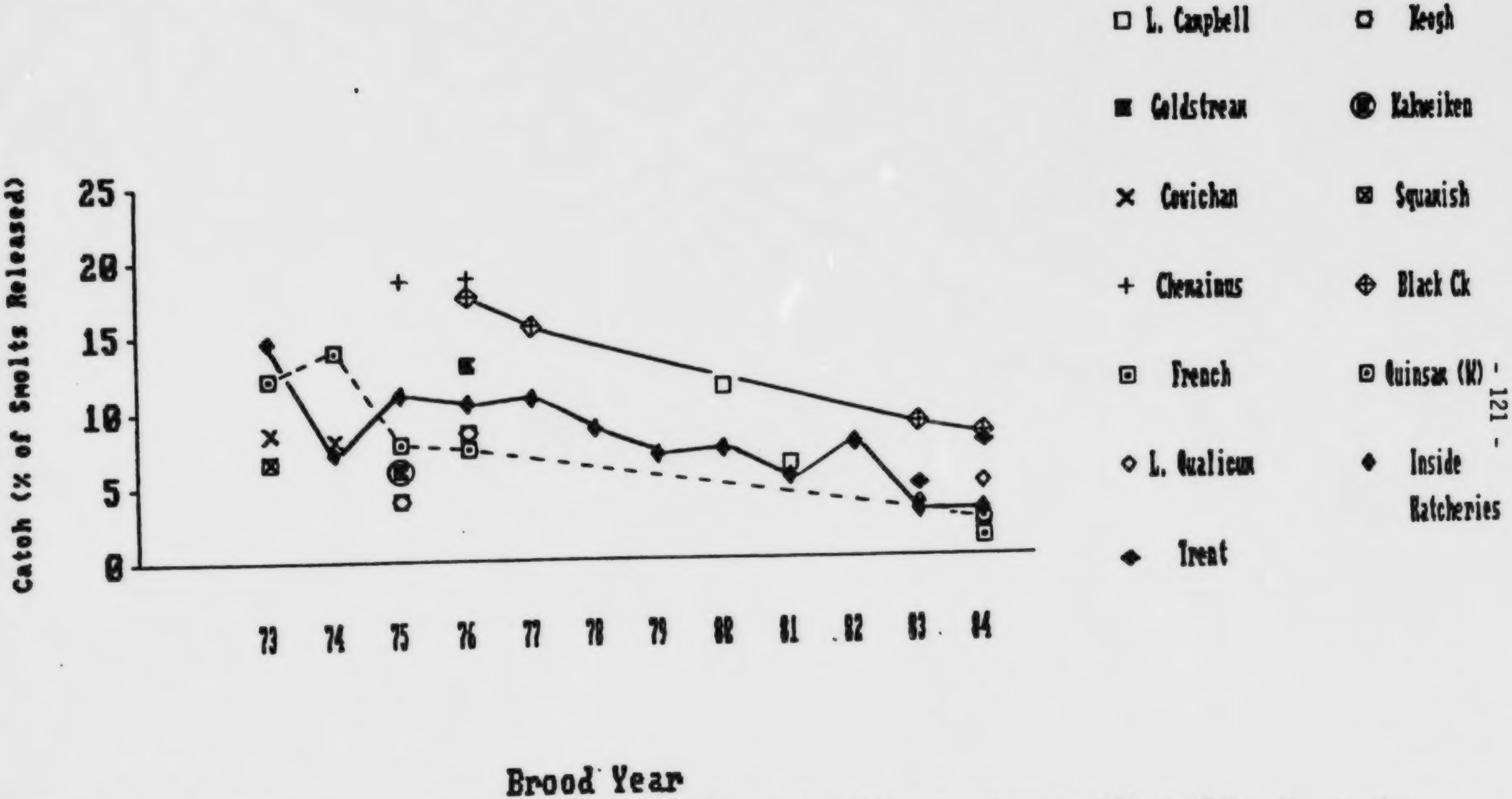


Figure 14.2. Survival-to-catch of Inside wild coho smolts marked during brood years 1973 to 1984. Comparative data for hatchery smolts released from all Inside hatcheries is presented.

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 88-2

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA SHELLFISH FOR 1989

At its meeting on September 16, 1988, PSARC reviewed the Shellfish Subcommittee Report as contained in this document.

This report is a summary of advice and recommendations resulting from the PSARC Shellfish Subcommittee, held August 30 - 31, 1988 at Dunsmuir Lodge, Sidney, B.C. Presentations were made by staff from the Shellfish Section, Pacific Biological Station, Biological Sciences Branch and biologists from the North and South Coast divisions of the Fisheries Branch. D. McKone represented the Biological Sciences Directorate Ottawa.

Shellfish fisheries (Table 1) have grown rapidly in the past five years, with participation by over 500 vessels and in excess of two thousand intertidal harvesters, many of which rely on shellfish fisheries for a major portion of their income. Shellfish are also increasing in interest and value to the recreational fishery and estimates of 37,000 sport fishermen have been made.

The landed value of invertebrate fisheries was about $35 million (including flying squid and oysters) in 1987, triple that of 1982 (Table 2), and shows some promise for further increases. Table 2 ranks the species according to total landings (tonnes) and total landed value over the past five years and shows trends in landings along the coast. Table 3 shows trends in landings for some species in the major fishing areas.

Recommendations from this subcommittee in 1987 formed the basis of 1988 fishing plans. Appendix 3 details actions that resulted from recommendations made from this subcommittee in 1987 for management and research programs. Considerable work has been accomplished and initiated, but important work has not been initiated due to lack of resources. As a result, many recommendations this year are the same as in the past and are still regarded as high priority.

MANAGEMENT POLICY

Management policies have been outlined, based on discussions and advice set by the Regional Shellfish Working Group.

MAJOR FISHERIES

Crab Fisheries: Entry is not limited.

- A minimum size limit protects a breeding stock of males and females.
- Some closures are set for time periods, when many crabs have soft shells, to improve quality and reduce handling mortality.

Prawn Trap Fisheries: Entry is not limited.

- In season monitoring is carried out to allow a minimum escapement of the spawning cohort of prawns within a management area.
- Trap escapement modifications are in place to maximize the economic yield and reduce handling mortality of prerecruits.
- Study areas are in place to examine alternative management options.

Intertidal Clams: Entry is open to anyone with a personal commercial fishing licence. Support vessels are not licenced.

- Minimum size limits allow clams to spawn at least twice before being taken in the fishery.
- Some beaches are closed seasonally to reduce mortality of sublegal clams from repeated harvesting or due to high risk of paralytic shellfish poison (PSP).
- The north coast is closed to harvesting, with the exception of razor clams, due to high risk of PSP.

Geoduck: This is a limited entry fishery with 55 vessel licences.

- Management by maximum sustained yield proposed at annual exploitation levels of 0.75 to 2% of the original biomass.
- Quotas are set to limit the growth of the fishery until more is known about recruitment and biomass.
- Quotas and seasons have been adjusted to provide a year-round supply.
- P licences have been issued in the north coast, where shore-based processing is not available.

Sea Urchin: Entry not limited.

- Area and subarea quotas have been set to limit growth of the fishery while biological data is obtained.
- Quotas for some areas (17, 18, and 19) are based on survey data and observed recruitment rates.

- The season in the south coast has been limited to the period October 15 to February 15, traditionally the period of peak demand and highest prices. The north coast has been open year round, with only minor landings.
- P licences have been issued for the north coast.

Abalone: This is a limited entry fishery with 26 individual and equal quota licences.

- A single, coastwide quota was originally set, based on sustained yield (from preliminary estimates of the original biomass and turnover rates). Quotas have been reduced and maintained at low levels, based on surveys of relative abundance and recruitment as compared to earlier surveys.
- The current size limit is intended to allow abalone to spawn two to three times before being taken in the fishery.

Sea Cucumber: Entry is not limited.

- Arbitrary quotas have been set for three regions of the coast (500 tonnes for each) to limit growth of this fishery until further biological data is obtained on growth, age and recruitment.

Shrimp Trawl: This is a limited entry fishery with 249 vessel licences.

- There are several species and stocks of shrimps exploited. Generally, the stocks are managed as inshore and offshore.
- It may be possible to manage inshore stocks on a sustained yield basis. Biological data are being collected by a mandatory logbook program, but to date there have not been any restrictions on the fishery.
- Conservative quotas have been set for the offshore stocks on the assumption that there may be a stock-recruitment relationship and a sustained yield is possible. Offshore stocks have shown high fluctuations in abundance. Further research is required to determine the optimal size or age to harvest in periods of peak abundance.

Offshore Squid: This in an exploratory fishery requiring special licences.

MINOR OR DEVELOPING FISHERIES

Most of the minor or developing fisheries are currently regarded as underutilized. Their growth has been limited because of the lack of markets.

The management policy in general has been to allow these fisheries to proceed with few restrictions but to require logbooks to document catch, fishing effort, and locations of harvest. This is the case for the minor crab species, squid, octopus, gooseneck barnacles, horse clams, and mussels.

Specific fishing limitations have been set for euphausiids (quotas) and for scallops (size limits).

Euphausiids - Plankton: A conservative quota (500 tonnes) has been set for inshore waters (Strait of Georgia and adjacent waters). The quota is based on a harvest rate of 0.1% of the estimated standing stock of euphaussids in the Strait of Georgia. Exploitation at this low level should not impact on the stock.

Scallops: Minimum size limits have been set to allow the scallops to spawn at least once, and possibly two or more times, before entering the fishery.

MAJOR FISHERY CONCERNS (1988)

Many of the specific fishery concerns identified in 1987 remain unchanged for 1988. Little is known about the abundance and recruitment of commercially harvested shellfish species. Market demand and subsequently prices remain strong for established and developing fisheries. Because of the number of shellfish species, their often unique biology, and limited resources available for research and management, arbitrary quotas have been established for many developing fisheries until such time as sufficient biological information exists to suggest alternative management strategies.

1. Closures for soft shell crab were implemented in the Fraser River estuary and at Tofino. Concerns were expressed about the increase in effort and the number of traps.

2. Processors and fishermen question the minimum size limit for sea urchins and have requested it be either reduced or eliminated.

3. Arbitrary quotas were set for the sea cucumber fishery, resulting in early closures in the south coast.

4. Offshore shrimp stocks are at the highest level of abundance in 1987 and 1988 since the 1970s. There is, however, evidence to suggest a decline in abundance in 1989. This fishery has been traditionally a boom or bust fishery and there are concerns investment in vessels, licences, and equipment may exceed levels that could be realistically supported by the fishery. Catch and effort should be closely monitored for this fishery. In addition, a survey is recommended in order to determine recruitment of marketable shrimp to the fishery and be predictive of fishing potential in 1989 and 1990.

5. Conflicts between commercial and recreational clam diggers and commercial diggers and property owners occurred on several occasions during the past year. Many communities are requesting recreational reserves, where commercial fishing would be prohibited. One of the most serious conflicts was at Savary Island (Area 15) which is the most important manila clam beach in the Province. Savary Island is important to the commercial clam industry and it is felt that with closer monitoring in the area, most of the conflicts can be avoided.

SUMMARY OF ADVICE FOR SHELLFISH (INVERTEBRATE) FISHERIES IN 1988

Section 1 discusses the fisheries of major importance in 1988, those with the greatest landings and highest values as shown in Table 2. These include crab and prawn trap fisheries, intertidal clams, diving fisheries for geoduck, sea urchin, abalone and sea cucumber and the offshore shrimp trawl fishery.

Other species support only minor fisheries at this time, and are discussed in Section 2. This includes plankton, minor crab species, inshore squid, scallops, horse clams, octopus, goose barnacles, and mussels.

SECTION 1 - MAJOR SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES
- CRAB (I88-3)
- PRAWN (I88-5, 7, 8)

INTERTIDAL FISHERIES
- INTERTIDAL CLAMS (I88-1, 2)

DIVING FISHERIES
- GEODUCK (I88-11, 12)
- SEA URCHIN (I88-15)
- ABALONE (I88-10)
- SEA CUCUMBER (I88-14)

NET FISHERIES
- SHRIMP TRAWL - OFFSHORE AND INSHORE (I88-6)

SECTION 2 - MINOR OR DEVELOPING SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES
- TANNER, KING AND GALATHEID CRABS (I88-4)

NET FISHERIES
- INSHORE SQUID (LOLIGO)
- PLANKTON - EUPHAUSIIDS (I88-9)

DIVING FISHERIES
- SCALLOPS
- HORSE CLAMS
- OCTOPUS

INTERTIDAL FISHERIES
- GOOSENECK BARNACLES
- MUSSELS

SUMMARY OF BIOLOGICAL ADVICE AND INFORMATION NEEDS FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1989

Major Fisheries	Biological Advice and Information Needs
TRAP	
Dungeness crab	1. No advice. Research in progress
Prawn	1. Continue current experimental management in the study areas and the mandatory harvest logbook program.
	2. Utilize standardized spawner indices for inseason management.
	3. Delay openings of intensive fisheries to take advantage of rapid spring and early summer growth to maximize yield-per-recruit.
INTERTIDAL	
Intertidal clams	1. Rigorous enforcement of minimum size limits.
	2. Assess magnitude of incidental mortality to juvenile clams due to repeatedly digging beaches.
DIVING	
Geoducks	1. Maintain current quotas. Continue harvest logbook program. Review existing logbook information and stock survey methodologies.
Sea urchins	1. No stock assessment. Restriction of effort by quotas or other means is recommended. Continue harvest logbook program.
	2. 55 mm minimum size limit proposed for green sea urchins.
	3. Collect biological data to provide life history information related to recruitment, growth, maturity and other factors.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1988 (cont'd)

Major Fisheries	Biological Advice and Information Needs
Abalone	1. No stock assessment. Maintain quotas at current low levels. Enforce minimum size limit. Continue harvest logbook program.
Sea cucumber	1. Reduce quotas to 500 tonnes for the north coast (to be divided among 3 areas) and to 300 tonnes for the south coast.
	2. Consider some form of experimental management.
	3. Continue harvest logs.
NET	
Shrimp trawl	1. Projected biomass for 1988/89 west coast of Vancouver Island stock is expected to be lower than in 1987/88.
	2. Closely monitor stock and fishing on west coast of Vancouver Island. Review quota options.
	3. Continue mandatory logbook program.
	4. Delay opening the fishery until June or July to take advantage of rapid growth in the spring and early summer in an effort to maximize yield-per-recruit.
Offshore squid	1. No advice.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1988

Major Fisheries	Biological Advice
TRAP	
Tanner, king, and galatheid crab	1. No stock assessment. Maintain current harvest logbook program.
Shrimp by trap	1. Continue monitoring of landings and effort (Sooke). TAC not evaluated.
NET	
Squid inshore	1. No advice. Underutilized. Continue harvest logs.
Plankton	1. No stock assessment.
	2. Continue monitoring catch and effort. Maintain harvest logbook program.
	3. To limit local overfishing, divide the current 500 tonne quota for the Strait of Georgia into area quotas such that not more than 50 tonnes is harvested from any single distinct geographical area.
DIVING	
Scallops	1. No stock assessment. Continue harvest logbook program.
Horse clams	1. No stock assessment. Monitor catch and effort data. Continue harvest logbook program.
	2. Evaluate habitat - occurrence in areas of vegetation supporting herring spawn.
Octopus	1. No stock assessment. Underutilized. Continue harvest logbook program. Allow experimental fishing with different gear types.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1988 (cont'd)

Major Fisheries	Biological Advice
INTERTIDAL	
Gooseneck barnacles	1. No stock assessment. Monitor landings, continue harvest logbook program.
Mussels	1. No stock assessment. Minor fishery. Monitor landings and continue harvest logs.

SECTION 1 - MAJOR SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES

DUNGENESS CRAB (I88-3)

Overall landings in 1987 were 22% greater than in 1986. Tofino was the major crab fishery in British Columbia and for the first time landings there exceeded those in the Fraser River fishery. In an effort to minimize capture of soft-shell crab, a fishery closure was implemented for the first time in the Tofino fishery from May 7 - June 30.

One presentation on crab discussed current ongoing research programs. Factors affecting recruitment to the Tofino crab fishery were summarized. There has been relatively poor settlement of megalopae in the Tofino area in 1986 and 1987 but there is evidence of substantial recruitment in 1988. Results of research indicate the fishery is now entering a period of 2-3 years of relatively low landings but it may improve in 1991 because of good recruitment in 1988. No formal review of this paper was done.

Recommendations

1. Studies of recruitment in the Tofino crab fishery should continue and should include monitoring of pre-recruits and mortality studies of pre-recruit males. Further research should include studies on the effect of closures in the fishery because of soft-shell condition.

PRAWN TRAP FISHERY (I88-5, 7, 8)

Prawn catch in 1987 was 618 t ($4.3 million) representing a 13% increase over 1986 levels. CPUE declined slightly in 1987 (0.24 kg/trap in 1987; 0.26 kg/trap in 1986) compared to 1986, although effort showed a slight increase (2.3 million trap days 1987; 1.8 million trap days 1986).

As recommended in last year's PSARC report, minimum mesh size regulations for prawn traps were implemented April 1, 1988. The regulations cover all types of traps currently employed by industry from wooden box to stretched nylon web cone stackable traps.

Experimental management of the southern study areas continued in 1987. The primary statistic of interest was the monthly spawner index. This index provides an estimate of the number of spawning females in the population and allows managers to, in theory, maintain a minimum spawning potential for the stock. One of the objectives of the experimental management program is to manipulate this index in order to determine if a relationship between stock size (as measured by the spawner index) and recruitment exists.

Three PSARC working papers were presented at the meeting. Two (I88-5, 7) dealt directly with the manipulation of the experimental areas while the third (I88-8) explored the potential of using inorganic markers for stock identification.

The first paper (I88-7) provided a review of current, on-going, and future initiatives in the experimental prawn study areas. The three southern areas (Howe Sound, Salmon/Sechelt Inlets and Alberni Inlets) have been manipulated most actively primarily due to their close proximity to research staff and their importance to the industry. The paper provides a brief summary of available fishery and biological data as well as research programs directly related to management initiatives. These include: (i) commercial logbooks (maintained at PBS); (ii) commercial sampling to obtain biological information such as size, sex, and age composition of the commercial catch; (iii) independent survey cruises to provide information for effort standardization, independent estimates of abundances, estimates of size, sex, and age composition of the total population, and the impact of fishing on the prawn populations (typically survey cruises have occurred just prior to and following a fishery); (iv) tagging studies to provide information on movement and abundance; (v) larval studies to identify critical stages in the life history that may influence recruitment to the fishery; (vi) stock identification studies; and (vii) data verification through checks of other information sources such as the fishing activity logbook program.

The paper provides information on catch and effort for each of the three southern experimental areas for 1986 and 1987. The openings for the spring fishery in Howe Sound were delayed in 1987 to July (compared with May in 1986) to take advantage of rapid growth in the late spring and early summer. The net effect of this experiment was that although fewer prawns were caught, the total weight of prawns harvested increased due to the increase in average size. Similar openings are scheduled for 1988.

The paper points out that the three southern areas have been fished heavily in recent years and the spawner indices are below target levels. While this is consistent with the experimental management of these areas, a period of rebuilding is required. This will mean some areas will be closed sooner than in the past with some negative impacts to industry.

Recommendations

1. Continue current experimental management in the study areas and the mandatory harvest logbook program.

2. Delay openings of intensive fisheries to take advantage of rapid spring and early summer growth to maximize yield-per-recruit.

The second paper (I88-5) summarized the results of a number of experiments designed to measure the relative efficiency of various prawn traps employed by industry. Some of these results have appeared previously in primary and secondary publications. Relative efficiencies varied by more than a factor of two for different traps fished under identical conditions. Unless standardized, information such as the age composition or spawner index may lead to serious mistakes in the management of prawn populations.

Subcommitee Discussions

Concern was expressed about employing the standardized spawner indices in the future when in the past some decisions were made on the basis of unstandardized data. Although all agreed the standardized information should be utilized, the concern was industries perception of the Department's change in management strategy.

Recommendations

1. Utilize standardized spawner indices for in-season management.

The third paper presented (I88-8) outlined preliminary results of a study on the potential use of inorganic elements for stock identification of prawn populations. Analyses were conducted to determine if certain inorganic elements found in specific body parts or in different aged prawns could be used to distinguish between prawn stock from various geographic areas. While preliminary results are encouraging, perceived differences have yet to be confirmed through independent techniques such as the use of genetic information or parasite loadings (i.e. number and types of parasites).

INTERTIDAL FISHERIES

INTERTIDAL CLAMS (I88-1, 2)

Total landings of intertidal clams, butter (Saxidomus giganteus), littleneck (Protothaca staminea), manila (Tapes philippinarum), and razor (Siliqua patula), increased sharply (50%) in 1987 compared to the previous year and value increased 80% to $6.75 million. Except for razor clams, virtually all landings were from the south coast district.

As in the past four years, the main species landed was manila clams. Landings almost doubled in 1987 compared to the previous year, and the value increased 1.2 times to $6.0 million.

Landings of littlenecks increased 30% over the previous year to373 t (Fig. 1) and the value increased 45% to $473 K. (Landings of littleneck and manila clams were slightly higher because most of the mixed clam landings are a mixture of these two species.)

Butter clam landings declined to 69 t with a value of $40 K. For many years butter clams were the dominant and most valuable species landed in the commercial fishery, but high production costs apparently make it uneconomic to process this species.

Razor clam landings were all from statistical Area 1 and remained at similar levels to 1986 to 142 t with a value of $126,000. The main reason for increased razor clam landings was that part of the catch was processed for human consumption rather than used entirely for crab bait.

Clam Farming

Minor attempts to farm manila clams continued, mainly in Areas 23 and 24.

Fishery

Regulation was by size limit which it was believed to be the only practical method to manage intertidal clam resources in British Columbia.

Two papers were presented that discussed Theoretical Mortality Rates of Intertidal Clams and Their Effect on Yield Estimates (I88-1) and a review of Survey Techniques for Intertidal Clams (I88-2).

The first paper (I88-1) indicated that, at least from a theoretical perspective, substantial decreases in yield-per-recruit may result due to incidental mortality to sub-legal size clams. The magnitude of the decrease is a function of the incidental mortality rate and the number of times the beach is dug. The incidental mortality, in essence, artificially inflates the natural mortality rate for sub-legal clams resulting in decreased survival to legal size. An experiment was outlined in this working paper (I88-1) to quantify the incidental mortality rate and the effect of multiple diggings.

The second paper (I88-2) outlined several possible methods of surveying clam beaches and analyzing the data collected. The basic assumptions of each approach were discussed as well as the advantages and disadvantages of each method.

Study Areas - Intertidal Clams

A clam "atlas" of beaches in the south coast division, for each management area, was updated in 1987.

Areas to study clam populations, assess recruitment and determine the affects of fisheries on clam populations have been established at Nanoose, Gabriola Bar (Area 17), Savary Island (Area 15), Seal Island (Area 14), Clayoquot Sound (Area 24), Mary Basin (Area 25), and Metlakatla Bar (Area 4). Two other study areas should be located in the Alert Bay area (Area 12) and the Gulf Islands region (Area 18). In the past year, sampling was done at Nanoose, Gabriola Bar, Savary Island, Clayoquot Sound, and Metlakatla Bar. It is proposed to increase sampling in these study areas in the next year.

Recommendations (Intertidal Clams)

1. Management of commercial clam harvesting should continue to be by strict enforcement of existing size limits.

2. Work in study areas should be increased to provide further biological information for management of the resource.

DIVING FISHERIES

GEODUCK CLAM (I88-11, 12)

Total landings of geoduck clams increased slightly (15.7%) in 1987 compared to 1986. Landings in the north coast increased to 2202 t (38% of total landings). Virtually all of the other landings were from the south coast.

The fishery is managed by limited entrance (55 licenses) and area quotas. Management since 1984 has tried to maintain a year round supply by staggering openings and quotas over the year to provide fishing opportunities to supply the live market. Efforts succeeded in 1987 but there will be a shortage in 1988.

The trend to harvest in deeper water continued in 1987. Most fishermen now plan for low tide periods to increase their diving time and reach deeper stocks. For the first time records of dives from 21-24 m were recorded.

Exploratory fishing was permitted in the north in 1987 and 1988 but several of these areas will have quotas assigned for 1989. These quotas are most often less than the arbitrary quota ceiling. Harvesting by P licence continued in the north and the number of vessels increased to 10 in 1988.

Fishing Area Estimates

No new data were avaiable for calculating stock densities. Densities of removals were calculated from logbooks. Because of low density removed from the inside waters of the south coast, it is believed that the area is greatly overestimated.

The overall CPUE for vessels and divers increased slightly in 1987 over 1986. CPUE for vessels declined in the north coast even though CPUE for divers increased.

Recommendations

1. Quotas should be maintained at current levels until some further stock assessment is carried out.
2. Research is required to review fishing areas, stock densities and standing stock estimates.

RED SEA URCHIN FISHERY (I87-9)

The fishery for red sea urchins increased only slightly in 1987, (2.4%) to 2,123 t in 1987. Growth of the fishery has been limited by seasons and area quotas in the south coast district which is based on fears of overfishing. The north coast has been open without quotas or seasonal restrictions. Most of the effort has been expended in the Central Coast, 295 t in 1987 with most of the catch (270 t) in areas 7 and 8. No quotas have been implemented in the north coast district because of the large area and lack of stock assessment. Management has been by minimum and maximum size limit and rotational openings. The present minimum size limit is 100 mm test diameter although this is under review at the request of the industry.

It is expected that the fishery will continue to expand in 1988 and 1989, particularly in the north coast area. A processor has established a plant near Prince Rupert to process red sea urchins. Because of the year-round opening in the north coast processors have realized there is a suitable product available for the market at nearly all times of the year.

Recommendations

1. Limitations for the south coast district should be maintained.

2. Biological investigations to determine age composition and age at maturity should be undertaken in the north coast district to provide information for setting size and seasonal closures.

3. Biological investigations to determine whether lowering of the size limit is justified should be undertaken.

GREEN SEA URCHIN

A new dive fishery for green sea urchins, (Strongylocentrotus droebeachiensis, developed in British Columbia in 1987 and landings reached 100 t. All landings were from the south coast district. Processors preferred green sea urchins with a test diameter larger than 45 mm. Animals smaller than this did not always contain roe.

Preliminary measurements of size frequency distribution of commercial catches was undertaken, most of the catch was over 50 mm test diameter. One field assessment was carried out in area 19.

The fishery was controlled by requirement of a Scientific Permit which limited harvest to the inside waters of the south coast. As many as 28 vessels participated in the fishery many of which also participated in the red sea urchin fishery. Most of the landings (75%) came from areas 13 and 19. Landings were generally at shallow depths which permitted divers to harvest for long periods of time without a necessity for decompression.

Mean catch was approximately 0.7 t per vessel day. Daily catches were dependent on the number of divers employed, most vessels had two divers. Mean diver CPUE was 151 kg per hour.

Recommendations

1. A study of the biology of the green sea urchin should be undertaken to provide information for management of the fishery.
2. A harvest logbook should be continued as a condition of the fishing license or permit.
3. Areas should be closed to harvesting for research studies.

ABALONE (I88-10)

The northern abalone (Haliotis kamtschatkana) fishery in British Columbia is a limited entry fishery, managed with 26 vessel quotas. Quotas have dropped, as stock was seen to decline, to the 1985 level of 47 t where they have remained. Demand continues to exceed supply and the price has increased over the last year (to $20 per kg).

Recommendations

1. The quota remain at the same level (47 t) for the 1989 season.
2. The survey methodology for determining the index of abundance be examined and developed as necessary.
3. Objectives of management should be reassessed at working group levels with the possibility of the reduced season implementated in 1988 being continued in 1989 in an attempt to reduce the opportunity for poaching.

SEA CUCUMBERS (I87-10)

The sea cucumber fishery has increased fourfold since 1985 (landed weight). The fishery expanded to the north coast at the end of 1987, taking the quota for the first time. All quotas were landed early in 1988. In reviewing the catch statistics, it is apparent that there are problems in obtaining timely and accurate inseason catch information resulting in the quota being exceeded in 1986 and 1987.

Recommendations

1. A greater effort is required to ensure accurate and complete information is provided in the logbooks and ensure catch information is obtained in a timely fashion in order to be useful for inseason management actions.

2. Effort should be limited until further biological data are obtained. Some evidence indicates current levels of harvest may not be sustainable in certain areas.

NET FISHERIES

SHRIMP TRAWL FISHERY (I88-6)

INSHORE TRAWL

Total landings from the major inshore shrimp grounds (Areas 14, 17, 18, 28 and 29) has been declining since 1983 (303 t in 1983; 189 t in 1987). However, from 1986 to 1987, catch declined substantially only in Area 17 (41 t to 17 t). As in 1986, Areas 28 and 29 continue to produce the target landings (62 and 67 t, respectively). No 1987 effort data are yet available to compare CPUE.

OFFSHORE TRAWL

West coast Vancouver Island shrimp stocks in 1987 had increased substantially from previous years. The 1987 estimated biomass of 5400 t was the largest observed since 1976. In 1988, biomass was estimated to be 4500 t but with a greater percentage of age 3 animals than observed in 1987 indicating a decline in stock abundance for 1989. The 1987 catch of about 2000 t was the largest quantity landed since 1977 (2600 t).

A shrimp biomass survey of the Tofino grounds, fisheries statistical area (FSA) 124 and to a lesser extent Nootka grounds, FSA 125, was conducted April 28-May 8, 1988. This type of survey has been conducted on these grounds 12 times in the spring (April-May) and 3 times in the later summer (August-September) since 1973. The purpose of these cruises is to provide relative estimates of total biomass, year-class abundance, and distribution of the smooth pink shrimp, Pandalus jordani.

The results of this survey are reported in PSARC Working Paper I88-6. In addition to estimating total abundance and year-class strength, this paper also presents a yield-per-recruit analysis to determine the optimal timing of fishing. The results of the analyses indicate that a 20% increase in yield-per-recruit could be realized if the fishery opening was delayed until August instead of April. The optimal timing appeared insensitive to changes in both natural and fishing mortality. However, delaying the fishery until August may mean that industry would not have sufficient time to harvest the available stock prior to the onset of bad weather in the fall. Opening the fishery in mid-June would result in only a slight decrease (5%) in yield-per-recruit but would likely allow sufficient time for industry to exploit the stock.

Recommendations

1. Continue monitoring catch and effort information for these stocks through the sales slip and logbook programs.
2. Delay opening the fishery until June or July to take advantage of rapid growth in the spring and early summer in an effort to maximize yield-per-recruit.
3. Projected biomass for 1988/89 west coast of Vancouver Island stock expected to be lower than in 1987/88.

SECTION 2 - MINOR OR DEVELOPING SHELLFISH (INVERTERBRATE FISHERIES)

TRAP FISHERIES

KING, TANNER, AND GALATHEID CRABS (I88-4)

In early 1988, a vessel was granted a Scientific Permit by the Offshore Division to fish tanner crabs (*Chionocetes tanneri*) off the west coast of Vancouver Island. Initial catches were promising and it is expected that this fishery will continue in the future. This species has not been previously commercially targeted for in the eastern Pacific Ocean and there is currently no restrictive regulation as to what size animals should be exploited to conserve the resource and achieve maximum yield-per-recruit.

One PSARC Working Paper (I88-4) was presented outlining initial analyses of morphometric data collected during research cruises and from commercial vessels. The purpose of this research is to determine if tanner crab growth and maturity characteristics are similar to those of the *C. opilio* crab exploited on the east coast of Canada. Other researchers have hypothesized that *C. opilio* reach a terminal molt stage which has caused significant changes in the size and nature of the fishery. Since the fishery for tanner crabs is new and developing, it is important to determine if similar growth characteristics exist for this species.

NET FISHERIES

INSHORE SQUID (LOLIGO)

Landings for inshore squid (*Loligo*) in 1987 were 132 t ($86,000). *Loligo* is expected to continue as a minor, sporadic fishery in 1988.Logbook records should be continued, to document fishing effort, landings, and locations.

PLANKTON - EUPHAUSIIDS (I88-9)

The euphausiids quota of 500 t is set at a conservative level of 0.1% of the estimated standing stock of euphausiids in the Strait of Georgia. Although this quota has never been reached, 130 t were harvested in 1987 at a value of $102,000.

One PSARC working document dealing with euphausiids was presented at the meeting. The paper suggested some areas, particularly Hotham Sound, may be experiencing local overfishing. This assertion was made primarily on declining rates of CPUE and concerns expressed by fisherman in the area. The paper recommend the quota for the Strait of Georgia be divided such that no more than 50 t is removed from any distinct geographic area.

Recommendations

1. Continue harvest logs.
2. To limit local overfishing, divide the current 500 t quota for the Strait of Georgia into area quotas such that not more than 50 t is harvested from any single distinct geographical area.

DIVING FISHERIES

SCALLOPS

Landings of scallops increased slightly (6%) to 66 t in 1987. All commercial landings were either spiny, *Chlamys hastata* or pink scallops (*C. rubida*). One permit was issued to drag for weathervane scallops, *Patinopecten caurinus* but no commercial fishing occurred. A few weathervane scallops were taken in the recreational fishery at depths of about 18 m but amounts landed are unknown.

Most commercial landings (about 90%) were spiny scallops which reflected fishing methods. In 1987 all landings were from diving which occurs on rock reefs at shallower depths (18-30 m) the main habitat of spiny scallops. Pink scallops usually occur at deeper depths on softer bottom and are generally harvested by dragging.

Landings were from the South Coast and Fraser River (Gulf Islands) Districts and were fairly evenly distributed throughout the year reflecting a small but steady market. Most landings were from statistical areas 17, 18 and 29. Minor landings perhaps resulting from exploratory fishing were made in areas 12, 13, 14, 15, 16, 19, 21, 25 and 28.

No surveys of populations or catches were undertaken in 1987. A few problems were experienced with landings of undersized scallops (less than 60 mm shell height). A clear definition and illustration of how scallops are measured should be included in the forthcoming management plan. The previous recommendation to lower the size limit of pink and spiny scallops to 55 mm shell height was not enacted in 1987.

In 1988 a seasonal closure was instituted for pink and spiny scallops in statistical area 20-5 because of high levels of PSP.

A complaint has been received from the recreational fishery that rock scallops, Crassadoma gigantea, have been depleted in many areas of the Strait of Georgia. Dive clubs visiting specific sites in the Strait can cause serious depletion of rock scallop stocks in local areas. The suggestion has been made by people in the recreational fishery that consideration be given to lowering the daily bag limit or to institute a moratorium on harvesting rock scallops for a year or more.

Recommendations

Continue to monitor fishery by log books and occasional sampling.

HORSE CLAMS

Landings of horse clams increased to 355 t in 1987. Landings were made by 27 vessels (from the eligible 55 G license holders).

Fisherman do not distinguish between the two species of horse clams, Tresus capax, and T. nuttallii. However, because processors prefer large clams and fishermen are required to harvest at least 3 m below chart datum, most of the catch is T. nuttallii.

Most landings were from the Strait of Georgia, Areas 14 and 17. Most harvest occurred at depths of 6 m and deeper and in areas well removed from herring spawning grounds.

Limiting factors in development of this fishery are poor recovery rates, 10-13%, neck meat as opposed to 22% for geoducks. In addition processing costs are high for horse clams.

Little change was observed in the CPUE in the fishery in 1987.

Recommendations

1. Landings of horse clams should continue to be monitored by logbooks with some market sampling to determine species ratio in catches.
2. Observations of horse clams should be carried out in cooperation with the dive assessment teams for herring spawn.
3. Some surveys should be conducted in association with harvesters to examine species composition, abundance, size and distribution in active fishing areas.

OCTOPUS

Most octopus are currently taken by divers. Some divers now fish octopus year round as their major source of income. Octopus are also landed as incidental catch in trawl and trap fisheries. Octopus landings in 1987 were 130 t ($382,000). The fishery is expected to remain relatively small in 1898.

Recommendations

With current low level of exploitation, this species has low research priority and current management practices should be continued. A more detailed log for divers is proposed. Experimental fishing should be encouraged.

INTERTIDAL FISHERIES

GOOSENECK BARNACLES

This newly developing fishery still remains relatively small, with most interest currently in the Tofino and Port Hardy areas. Official landings indicate that only a few tonnes (32 t) have been landed in 1987, mostly from the Tofino and Port Hardy areas with a total value of $211,000.

Recommendation

With the current low level of exploitation, this species has low research priority and mandatory logbooks to be completed by harvesters should be continued.

MUSSELS

Landings of mussels declined slightly in 1987 to 2.6 t. Most landings are from culture opertions. Mussel culture is expected to continue to expand slowly in British Columbia.

Current research is focusing on examining differences in races of mussels in the Province to determine if there are differences in resistence to summer mortality.

Table 1. List of shellfish fisheries (20) in 1987.

Intertidal Fisheries (3)
Clams (littleneck, manila, butter, razor)
Mussels
Gooseneck barnacles

Diving Fisheries (7)
Geoduck
Horse clam
Sea urchin
Sea cucumber
Octopus
Pink and spiny scallops
Abalone

Net/Trap Fisheries (10)
Dungeness crab by trap
Prawn by trap
Shrimp by trap (coonstripe, humpback, pink)
Shrimp by trawl
Squid (inshore) by seine
Squid (offshore) by gillnet
Octopus by trap and trawl
Sea cucumbers by trawl (experimental)
Tanner crab by trap (experimental)
King crab by trap

Table 2. Landings of invertertebrate species in British Columbia from 1983-1987. Landings in tonnes, value in thousands of dollars.

	Landings (tonnes)				
Species	1987	1986	1985	1984	1983
Molluscs					
Intertidal clams[1]	4,279	2,849	2,926	2,615	1,762
Geoducks	5,789	5,005	5,370	3,482	2,636
Horse clams	355	96	6.3	7	21
Squid (inshore)	132	79	126	70.3	71
Squid (offshore)	-	627	-	-	-
Octopus	130	53	34	30.4	37
Scallops	66	71	53	26.6	11
Abalone	49	52	42	58	56
Mussels	1.5	2.2	-	-	-
Crustaceans					
Crab	1,618	1,321	1,165	1,155	960
Shrimp-trawl	2,371	768	678	409	377
Prawn	618	550	514	504	331
Plankton	130	166	122	93.9	50
Gooseneck barnacle	32	1.6	-	-	-
Shrimp-trap	21	4.6	-	-	34
Echinoderms					
Red sea urchin	2,123	2,074	1,815	1,834	982
Sea cucumber	1,722	786	346	113	-
Green sea urchin	100	-	-	-	-

[1] Intertidal clams					
Razor	142	142	90	101	31
Butter	69	159	252	131	77
Littleneck	373	285	192	295	325
Manila	3,608	1,894	1,914	1,677	1,049
Mixed	87	369	478	409	280

Table 2 (cont'd).

Species	Landed Value (X $1,000.00)				
	1987	1986	1985	1984	1983
Molluscs					
Intertidal clams[1]	6,758	3,740	3,144	2,758	1,727
Geoducks	6,242	4,296	4,786	2,937	1,819
Horse Clams	359	62	6	5	12
Squid (inshore)	86	119	139	86	95
Squid (offshore)	-	2,400	-	-	-
Octopus	382	125	68	64	80
Scallops	250	277	137	74	45
Abalone	973	500	442	530	464
Mussels	2.6	3.8	-	-	-
Crustaceans					
Crab	6,525	5,755	4,719	4,558	3,311
Shrimp-trawl	4,053	1,148	1,180	1,022	1,094
Prawn	4,285	3,732	2,461	2,304	2,154
Plankton	102	98	n/a	38	n/a
Gooseneck barnacle	211	4.7	-	-	-
Shrimp trap	73	12	-	-	-
Echinoderms					
Red sea urchin	1,123	895	762	740	354
Sea cucumber	759	225	91	26	-
Green sea urchin	126	-	-	-	-

[1] Intertidal clams

Razor	126	127	95	123	24
Butter	40	60	74	54	33
Littleneck	473	325	202	311	328
Manila	5,987	2,721	2,220	1,809	1,039
Mixed	132	507	553	454	291

Table 3. Landings (tonnes) for some invertebrate species in British Columbia, 1983-1987.

Year	North Coast District	West Coast Vancouver Island	Strait of Georgia/ Johnstone Strait
Geoduck			
1983	501.9	1,653.7	480.1
1984	574.2	1,734.4	1,174.3
1985	1,365.6	2,878.8	922.3
1986	1,692.7	2,194.3	1,107.9
1987	2,148.1	2,138.8	1,347.9
Intertidal Clams			
Manila			
1983	-	241.2	807.5
1984	-	386.3	1,291.0
1985	-	586.2	1,327.3
1986	-	384.5	1,507.6
1987	-	728.6	2,861.2
Littleneck			
1983	-	38.9	285.8
1984	-	78.4	215.8
1985	-	29.7	162.5
1986	-	27.6	257.2
1987	-	55.5	317.0
Crab			
1983	209.0	174.6	454.0
1984	294.1	161.0	696.1
1985	274.9	200.9	685.7
1986	317.8	306.6	695.7
1987	178.7	222.2	338.3
Shrimp			
1983	15.4	39.6	319.7
1984	27.3	40.6	323.9
1985	30.3	382.3	254.6
1986	35.8	1,056.8	22.0
1987	17.2	2,534.2	235.4

Table 3 (cont'd).

Year	North Coast District	West Coast Vancouver Island	Strait of Georgia/ Johnstone Strait
		Prawn	
1983	121.1	29.5	210.4
1984	127.0	53.5	339.2
1985	104.7	27.7	392.7
1986	136.9	11.8	394.6
1987	176.9	35.8	362.4
		Sea urchin	
1983	-	-	-
1984	2.2	193.2	1,563.2
1985	-	488.7	1,279.3
1986	11.8	571.3	1,481.3
1987	213.9	344.2	1,003.8
		Sea cucumber	
1983	-	-	-
1984	1.3	-	93.2
1985	-	26.6	317.4
1986	-	8.5	777.1
1987	78.1	404.6	653.7

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 88-3

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA GROUNDFISH FOR 1989

At its meeting on September 16, 1988, PSARC reviewed the Groundfish Subcommittee Report as contained in this document.

This document contains brief summaries of stock conditions of the important groundfish stocks, and recommendations for their management to the Offshore Division of the Fisheries Branch. The report is based on the more extensive report prepared by the staff of the Groundfish Section of the Biological Sciences Branch, located at the Pacific Biological Station, Nanaimo, British Columbia, Canada, V9R 5K6.

Department biologists begin their assessments in the spring of the year using a multi-year data base for fishery statistics and biological research. A variety of assessment models are used including several sequential analysis models, age-independent surplus production models, yield-per-recruit, and linear models. Assessments are completed in August after review by a Committee of DFO Groundfish scientists. Review may also incorporate outside investigators (government or non-government), where desired by the DFO Biological Sciences Branch. Assessments are then reviewed by the DFO Pacific Stock Assessment Review Committee and recommended yield options are collated and sent to the Offshore Division of Fisheries Branch for consideration.

Total Canadian landings of groundfish are given in Tables 1 and 2 of Appendix 1.

LIST OF ASSESSMENTS

Lingcod -- L. J. Richards and C. M. Hand
Pacific cod -- A. V. Tyler and R. P. Foucher
Flatfish -- J. Fargo
Sablefish -- M. W. Saunders, W. Shaw, and G. A. McFarlane
Pacific hake -- M. W. Saunders and W. Shaw
Dogfish -- M. W. Saunders
Walleye pollock -- W. Shaw and M. W. Saunders
Slope rockfish -- B. M. Leaman
Shelf rockfish -- R. D. Stanley
Inshore rockfish -- L. J. Richards and C. M. Hand

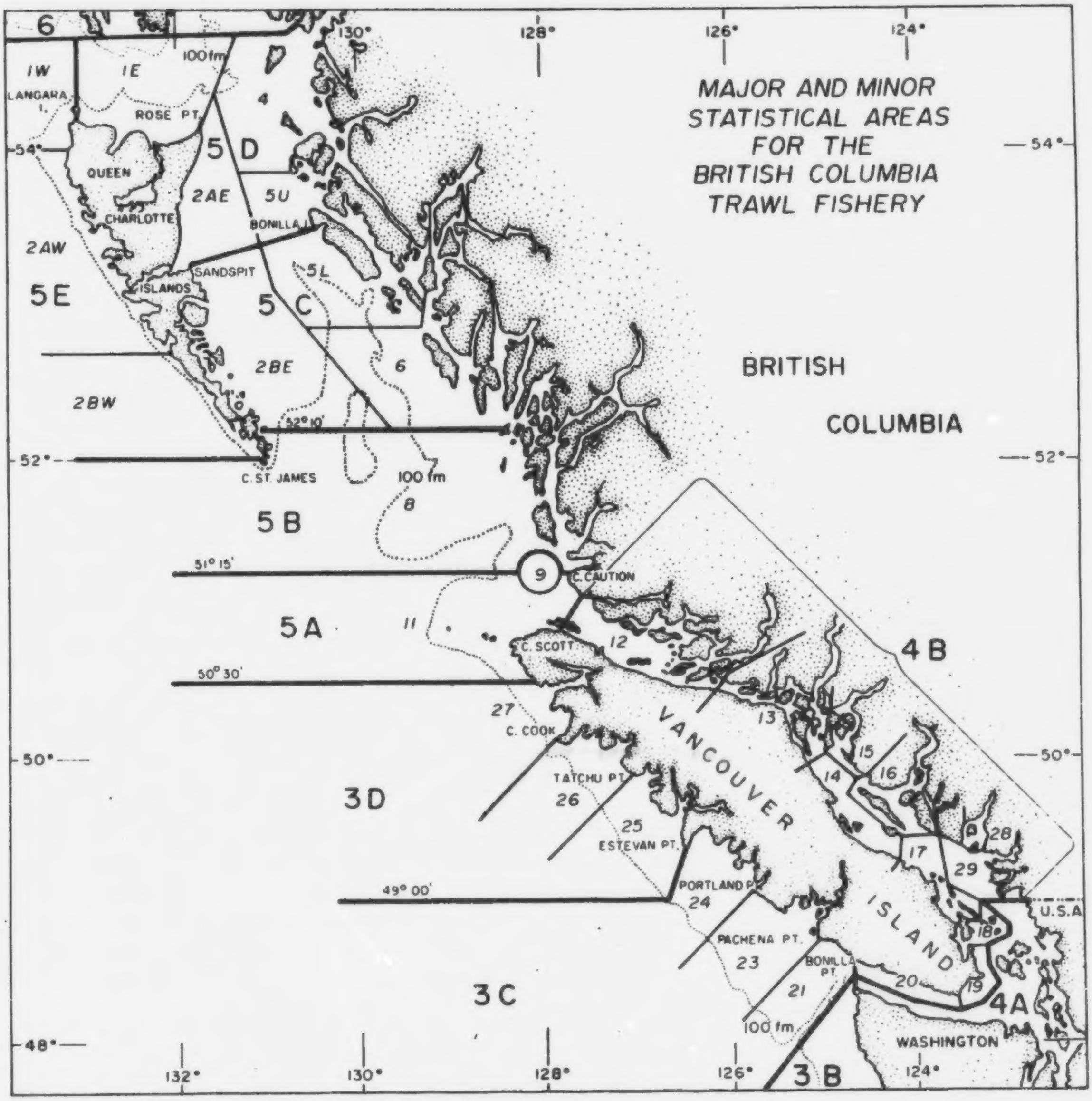


Fig. 1. International (Pacific Marine Fisheries Commission) Major and Minor Statistical Areas along the British Columbia coast.

MANAGEMENT POLICY

While management policy is not set by the stock assessment process, a statement on policy as it exists should help to provide the setting to understand the assessments. Policy is set by the managers in consultation with representatives from industry. The analyses conducted by assessment biologists address items of policy, and specific problems brought forward by management and industry.

The overriding objective of the present management approach is to achieve a 10-month trawl fishery. An annual quota is usually set if a stock is considered to be under sufficient fishery pressure to warrant concern. The managers and industry representatives then set quarterly sub-quotas and trip limits so that fishing opportunities are available through most of the calendar year.

In setting the annual catch quota, biologists are first concerned with maintaining a sufficient spawning stock to permit at least reproductive replacement of the capacity to produce. The ultimate goal for this high-volume, commercial fishery is to maximize potential catch in the long term, while taking into account natural long-term trends and year-to-year variation in natural production. When the data to derive these estimates are lacking, quotas are calculated that are least likely to cause a diminshed potential for production in the near future. Partly because of the uncertainty in the estimates, managers are usually given a range of yield options, as defined below.

YIELD OPTIONS

A number of levels of yield options are presented. All may not be appropriate to apply to a particular species or stock. The seven yield options are: (i) zero yield; (ii) rebuilding yield; (iii) sustainable; (iv) low risk-sustainable; (v) high risk-sustainable; (vi) non-sustainable and (vii) unrestricted yield.

(i) Zero yield

This option could be entertained under situations of known and severe stock depletion, or where particular areas may represent necessary refuges for the fish. Additional ecological considerations might include situations where the subject stock acts as a predator on a less desirable species, and the objective is to maximize predation.

(ii) Rebuilding yield

Under this option the probability of overfishing is minimized while that of rehabilitating depleted stocks is increased. With the exception of option (i), this approach will incur the lowest risk of deleterious effects on stock biomass and dynamics. It is also true that it represents a lower yield than could be taken out of the stock on a sustainable basis. The most common application of this option is for stock rebuilding although for rockfish stocks this should be the approach to developing fisheries, because of the detection, response and corrective time frames (10 - 20 y) for rockfish species.

(iii) Sustainable yield

This option provides some opportunity to maintain stocks at existing levels. In many ways this is the least certain of the options available since it entrains many assumptions about the behaviour of stocks in response to fishing and biological processes. This option should be taken to mean that the probabilities of either decline or increase in yield (biomass) are approximately equal. The term "sustainable" should be understood in its broad sense, i.e., that the stock will oscillate around the expected level as a result of oscillation in recruitment, rather than be maintained at a fixed level. The amplitude and frequency of these oscillations may vary considerably among and within stocks at different levels of biomass. In the simplest terms, this is our best estimate of the highest yield at existing stock levels.

(iv) Low-risk sustainable yield

Like the Sustainable Option this is an estimate of the tonnage that can be caught during the year and leave enough of the biomass for the stock to replenish itself through reproduction and body growth. However, data are often not as complete as should be for calculation of a single, firm estimate of the true value of the sustainable yield. When there is a high degree of uncertainity about the estimate, a cautious approach to setting the catch limits should be taken. The cautious or conservative estimate is often set simply as 50% or 75% of the calculated sustainable yield, depending on the biologist's understanding of the reliability of the estimate.

(v) High-risk sustainable yield

This catch limit has some small chance of being a sustainable yield. The estimate is at the other end of the range from the low risk-sustainable yield, and is above the Sustainable yield estimate. The level is often set simply as 25% or 50% higher than the sustainable yield value. Sometimes a central value for the sustainable yield is not given, only the low risk and high risk levels. Risk levels should only be selected to provide relief from a specific case of economic hardship, with conscious recognition be made that decreases to sustainable levels in the near future might be the result of selecting this option.

(vi) Non-sustainable yield

While the sustainable option is derived from the biological properties of the species and stock composition, the non-sustainable level is largely an economic and management concept. The benefits of increased yield over the short-term must be weighed against the lowered future yields resulting from overfishing. Employment of this option implies either experimental or non-biological management, since stock declines are highly probable with such a policy in effect over a significant part of the average life of a population cohort. This option might be considered when: socio/economic conditions require short-term yields in excess of sustainable harvest; experiments concerning well-defined and disparate exploitation rates are necessary; or, management policy requires sequential, pulsed fishing on several stocks.

This option requires that management will have to shift to a conservative policy to offset deleterious effects prior to major and irreversible stocks changes. Thus, this option either guarantees a pulsed exploitation pattern if the stock is to be maintained at the most productive level, or accepts short-term gains over long-term productivity.

The hazard associated with this option will vary with the biological characters of the target stocks. In particular, the residence time of a cohort in the vulnerable stock will be a key determinant in the time for detection and response. Where residency is long, higher than sustainable yields may be maintained over several years in spite of strongly deleterious, yet undetected effects on subsequent cohorts. Conversely, a short residency may permit more rapid detection of adverse effects although incremental increases in quotas should be small if uncertainty about effects is high.

(vii) Unrestricted yield

Few conditions would call for consideration of this option. Depletion of stocks and elimination of fisheries when harvests are uncontrolled are well documented throughout the world. However, this option might be considered: for experimental purposes; for stock eradication in the case of competing species.

(viii) Other measures

The trawl fishery for groundfish is characterized by a multi-species catch. Managers, biologists, and vessel captains have noted that there are two principal difficulties created because of the multi-species characteristics. (1) Biological interactions among species may interfere with the simultaneous, maximization of fisheries potential yield in all co-existing species. (2) Where there are several annual quotas on a group of co-existing species, the species quota that is taken first could close down fishing on the entire group. At present biological interactions are not explicitly built into the stock assessments. This is cause for avoiding the risk-sustainable options if at all possible. On the other hand, regarding problem 2, multi-species yield options are arranged so that premature closure for a whole group of species is unlikely. Trip limits have been used to spread the take of lower production species through the year. In a few cases species-mixture or group quotas are given, and an area not closed until the group quota is reached. Species ratios are checked for imbalance. If a gross imbalance is found the group quota is adjusted the following year.

MAJOR FISHERY CONCERNS

Major fishery concerns in the past year relate to the rockfishes. There is a disagreement between fishermen and biologists regarding the size of the standing stocks. The trawler captains believe that the stocks will support more catch than the annual quotas allow. Biologists have pointed out that the stocks are so slow-growing, that a large biomass is necessary in order to maintain the existing catch. There is both demonstrated and high potential risk of over-fishing. The species are very slow-growing and the populations have a slow turn-over rate. For example, individuals are 8 - 15 years old before they spawn for the first time. If a quota is set too high on a trial basis for 5 - 6 years, and overfishing occurs, it will take 25 to 30 years to repair the stock. Pacific ocean perch and yellowtail rockfish are among the species of concern.

Groundfish research staff have met with the industry's Deep Sea Trawlers Association (DSTA) to try to develop a joint DFO - DSTA rockfish survey. The minimum objective is to form a relative abundance trend series that both industry and fisheries staff will believe. The procedures are in an advanced state of planning, and a plan that is jointly agreeable should be in place within the next few months.

For inshore areas rockfish species (quillback, copper, yelloweye rockfish) are being taken in some locations of the Queen Charlotte Strait, Johnstone Strait, and Strait of Georgia at rates greater than can be supported by natural production. Strait of Georgia lingcod have been over exploited in the past and continue to be. There is evidence that the initial depletion of lingcod was due to the commercial fishery, but that the sports fishery now accounts for much of the present take, and must be controlled if rehabilitation is to ensue.

An additional problem which hampers effective management is a lack of formal objectives for each stock, and the fishery as a whole. This results in confusion as to the appropriate management protocols which need to be adopted when dealing with the mixed-species nature of the groundfish fishery, and the often opposing results of alternative actions. More effort is required in the development of stock-by-stock objectives and integration of these objectives into the overall groundfish management plan. The long-term economic tradeoffs of fisheries on short-lived, highly-dynamic vs. long-lived, stable species require analysis. The biological assessments produced by this Branch will form only one part of such an analysis. We are increasingly concerned that the biological and economic penalties arising from the lack of a more integrated management plan may be large and result in overall decreases in stock yields. By highlighting these concerns we hope to stimulate the process of developing an improved system.

Views on current condition of groundfish species/species groups on the west coast of Canada.

Species or species group	Current stock condition
Strait of Georgia lingcod	Low
Offshore lingcod	Average
Pacific cod	High
Petrale sole	Low
Rock sole, English sole, Dover sole, arrowtooth flounder	Average to high
Sablefish	Average
Pacific hake	High
Spiny dogfish	Average to high
Walleye pollock	Low to average
Slope rockfish	Low to average
Shelf rockfish	Average
Inshore rockfish	Low to average

The recommendations for west coast groundfish for 1989 are summarized below:

Area	Species	Management options
4B	Lingcod	1. Sub-areas closures. 2. Add time to winter fishing closure Nov. 15 - Apr. 30. 3. Introduce minimum size limit of 58 cm for sport-caught lingcod to protect young.
3C	Lingcod	1. Winter closure Nov. 15 - Apr. 30. 2. Low risk-sustainable: 900 t. 3. Sustainable: 1400 t 4. High risk-sustainable: no quota, fishing effort correlated with abundance.
3D, 5A, 5B, 5C, 5D, 5E	Lingcod	No options proposed.
4B	Pacific cod	No options proposed.
3C/3D	Pacific cod	Open fishing due to high abundance.
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod	Open fishing due to high abundance.
5E	Pacific cod	No options proposed.
Coastwide	Petrale sole	1. Sustainable: trip limit 44,000 lb.
4B	Flatfish	No options proposed.
3C/D	Flatfish	No options proposed.

Area	Species	Management options
5A	Rock sole	1. Sustainable: 100 t (30,000 lb trip limit). 2. Non-sustainable: 200 t.
5B	Rock sole	1. Low risk-sustainable: 200 t, 30,000 lb trip limit. 2. High risk-sustainable: 400 t. 3. Non-sustainable: 500 t.
5C	Rock sole	1. Low risk-sustainable: 500 t, 30,000 lb trip limit. 2. High risk-sustainable: 700 t. 3. Non-sustainable: 900 t.
5D	Rock sole	1. Low risk-sustainable: 500 t, 30,000 lb. trip limit. 2. High risk-sustainable: 850 t. 3. Non-sustainable: 1,000 t.
5C/D	English sole	1. Low risk-sustainable: 400 t. 2. High risk-sustainable: 600 t. 3. Non-sustainable: 800 t.
5C/5D/5E	Dover sole	1. Low risk-sustainable: 800 t quota, 20,000 lb/trip permitted after 75% of the quota is reached. 2. High risk-sustainable: 1,000 t quota 20,000 lb/trip permitted after 75% of the quota is reached.
Coastwide	Sablefish	1. Low risk-sustainable: 2,800 t quota. 2. Sustainable: 3,600 t. 3. High risk-sustainable: 4,500 t quota.
4B, not including MSA 19, 20	Pacific hake	1. Low risk-sustainable: 8,000 t. 2. Sustainable: 11,000 t. 3. High risk-sustainable: 14,000 t.

Area	Species	Management options
3C	Pacific hake	Yield options to be presented at a later date when all current biological information is collated in the joint Canada - U.S. assessment algorithm.
Coastwide (not including 4B)	Dogfish	1. Pulse fishing: variable annual quota until non-nuisance abundance reached. 2. Low risk-sustainable: 15,000 t in 3rd and 4th quarter of year. 3. Low risk-sustainable alternative: 9,000 t in 1st and 2nd quarter of years only. 4. High risk-sustainable: 25,000 t in 3rd and 4th quarter only. 5. High risk-sustainable alternative: 15,000 t in 1st and 2nd quarter of yearly only.
4B, not including MSA 12, 19, 20.	Dogfish	1. Pulse fishing: variable annual quota, see text. 2. Low risk-sustainable: 2,000 t annual quota. 3. High risk-sustainable: 3,000 t annual quota.
4B	Walleye pollock	1. Low risk-sustainable: 2,500 t quota. 2. High risk-sustainable: 5,400 t quota.
3C/3D	Walleye pollock	Options not proposed.
5A/5B	Walleye pollock	Options not proposed.
5C/5D	Walleye pollock	Open fishing option proposed.
5E	Walleye pollock	Options not proposed.

Area	Species	Management options	
Coastwide	Yellowtail rockfish	Low risk-sustainable: High risk-sustainable:	2,000 t. 4,000 t.
3C/3D	Silvergray rockfish	Low risk-sustainable: High risk-sustainable:	400 t 600 t
5A/5B	Silvergray rockfish	Conservative-sustainable: Risk-sustainable:	700 t 1,000 t
5C/5D	Silvergray rockfish	Conservative-sustainable: Risk-sustainable:	500 t 800 t
5E-S	Silvergray rockfish	No recommendation. Currently an incidental fishery.	
5E-N	Silvergray rockfish	No recommendation. Currently an incidental fishery.	
3C/3D	Canary rockfish	Low risk-sustainable: High risk-sustainable:	500 t 700 t
5A/5B	Canary rockfish	Low risk-sustainable: High risk-sustainable:	300 t 500 t
5C/5D	Canary rockfish	Low risk-sustainable: High risk-sustainable:	Unknown 500 t
5E-N/S	Canary rockfish	Low risk-sustainable: High risk-sustainable:	Unknown 500 t
3C (Including management Area 125)	Pacific ocean perch	1. Rebuilding: 2. Low risk-sustainable: 3. High risk-sustainable:	<100 t 100 t 200 t

Area	Species	Management options	
3C	Redstripe rockfish	Low risk-sustainable: High risk-sustainable:	200 t 1,000 t
3D	Pacific ocean perch	Low risk-sustainable: High risk-sustainable:	200 t 600 t
3D/5A	Yellowmouth	Low risk-sustainable: High risk-sustainable:	250 t 750 t
3D/5A	Redstripe	Low risk-sustainable: High risk-sustainable:	350 t 900 t
5A/5B	Pacific ocean perch	Rebuilding: Low risk-sustainable: High risk-sustainable:	<700 t 700 t 1,000 t
5C/5D	Pacific ocean perch	Low risk-sustainable: High risk-sustainable:	1,900 t 3,000 t
5C/5D	Yellowmouth	Low risk-sustainable: High risk-sustainable:	160 t 500 t
5C/5D	Redstripe	Low risk-sustainable: High risk-sustainable:	350 t 570 t
5E-S	Pacific ocean perch	Low risk-sustainable: High risk-sustainable:	300 t 500 t
5E-S	Yellowmouth	Low risk-sustainable: High risk-sustainable:	400 t 700 t
5E-S	Rougheye	Low risk-sustainable: High risk-sustainable:	200 t 300 t

Area	Species	Management options	
5E-S	Grouped slope rockfish (Pacific ocean perch, yellowmouth and rougheye)	January-June	
		Low risk-sustainable:	300 t
		High risk sustainable:	500 t
		September-December	
		Low risk-sustainable:	600 t
		High risk-sustainable:	1,000 t
5E-S	Redstripe	Low risk-sustainable:	50 t
		High risk-sustainable:	100 t
5E-N	Pacific ocean perch	Low risk-sustainable:	150 t
		High risk-sustainable:	170 t
5E-N	Yellowmouth	Low risk-sustainable:	350 t
		High risk-sustainable:	500 t
5E-N	Rougheye	Low risk-sustainable:	50 t
		High risk-sustainable:	100 t
5E-N	Redstripe	Low risk-sustainable:	500 t
		High risk-sustainable:	700 t
4B-MSA-12	Copper/ Quillback	Low risk-sustainable:	75 t
		High risk sustainable:	150 t
4B-MSA-13	Copper/ Quillback	Low risk-sustainable:	50 t
		High risk-sustainable:	100 t
4B-MSA-14-20, 28,29	Copper/ Quillback	Low risk-sustainable:	150 t
		High risk-sustainable:	250 t
4B	Yelloweye	Low risk-sustainable:	50 t
		High risk-sustainable:	100 t
3C/D	Grouped line rockfish	Low risk-sustainable:	60 t
		High risk-sustainable:	750 t
5A/B/C/D/E	Grouped line rockfish	Low risk-sustainable:	120 t
		High risk-sustainable:	870 t

TEXT SUMMARY OF YIELD OPTIONS

LINGCOD - AREA 4B STRAIT OF GEORGIA

Yield Options

Whatever the cause of the decline, it is apparent that lingcod stocks in the Strait of Georgia cannot sustain current levels of exploitation. As the sport fishery now takes a greater share of the catch dispite the bag limit of 3 fish, the managment strategy must involve both sport and commercial fisheries. Three management options are proposed. A combination of these options may provide the best management strategy.

(A) Closures of areas or subareas to reduce catch and fishing effort. As lingcod are relatively sedentary and probably recruit from localized areas, closure of areas should help to rebuild stocks in that area. A closure has been implemented in 1988 near Campbell River, but applies to the commercial fishery only. As the sport fishery now takes a greater share of the catch, closures must apply to both sport and commercial fisheries to be effective. Ideally, there should be several closed areas in different parts of the coast. These could be developed as experimental management areas, and the sport fishing community could be involved in assessing the impact of the closures. As lingcod are fast-growing, the benefits of closed areas might be more readily measured for lingcod than for other fish such as rockfish.

(B) A further extension of the winter spawning closure. This is a modification of Option A, in that all areas are closed for a period of time instead of a complete closure for selected areas. This option may not be as effective as (A). A winter closure has been in place for many years and has not been sufficient to halt the decline in stock abundance.

(C) A size limit of 58 cm for the sport fishery. This is the size limit in effect for the commercial fishery. At present, the sport fishery takes a high proportion of immature fish, and a size limit would increase the probability that fish spawn at least once before they are caught. A size limit is a reasonable option for lingcod. Although there have been no studies to examine release mortality, lingcod survival has been high in tagging studies. Further, the survival of lingcod is high for fish above the suggested size limit.

LINGCOD - AREA 3C - SW VANCOUVER ISLAND

Yield Options

Because of the risk of stock collapse, it is recommended that a quota on the Area 3C stock be maintained while abundance is low. The low risk-sustainable option is 900 t, the sustainable option is 1,400 t, and the high risk-sustainable option is unlimited yield. These options will be re-evaluated after studies are conducted on stock distribution. Due to the possible decrease in recruitment, it is also recommended that the winter fishing closure (Nov. 15 - Apr. 30) be maintained to protect nesting lingcod. Yield options are not proposed for Area 3D.

PACIFIC COD - AREA 3C - SW VANCOUVER ISLAND

Yield Options

With the stock appearing to be strong it is not necessary to impose any spawning-season closure for the first quarter of 1989 as has been done in recent years.

PACIFIC COD - AREA 5C/5D

Yield Options

The recommendation last year was that there be no quota or other restrictions to the fishery. The CPUE in 1986 was the highest for the previous ten years and in 1987 increased again, by 177% over 1986 levels due to the strong 1985 and 1986 year classes entering the fishery. These year classes are contributing strongly to the 1988 fishery and their effects should still be felt in 1989. Mortality rates are such, however, that by the 1990 fishery there will be little significant contribution from the 1985 year class. We again recommend no quota for the 1989 fishing year.

PETRALE SOLE - COASTWIDE

Yield Options

The yield options presented here are based on a "short term" equilibrium situation.

(1) Sustainable Option: A 44,000 lb trip limit regulation for petrale sole from January 1 - March 31 is in effect, coastwide. The January - March period corresponds to the spawning time for petrale sole, a period when these stocks are particularly vulnerable to exploitation. This regulation is the result of a request by industry aimed at reducing a target fishery on petrale sole while stocks are depressed. Recently, some members of industry have presented arguments against a "coastwide" trip limit for this species, particularly in light of catches of petrale sole in the free-fishing area north of 54 degrees latitude. At present we have no evidence that the petrale sole in the northern portion of Area 5E are part of the "northern" or "southern" stocks. In fact, available evidence indicates that a number of discrete stocks of petrale sole exist along the Pacific coast. Thus the trip limit for petrale sole could be considered applicable only to the west coast of Vancouver Island. However, area trip limits for individual species have created enforcement problems in the past.

(2) High Risk Sustainable Option: Previous analyses have all indicated that petrale sole stock size has no effect on year-class production for the species and the trip limit should be removed and free-fishing allowed. As a caveat to this option, all previous analyses concerning stock and recruitment for the species were conducted when petrale sole stocks were at significantly higher levels of abundance than they are at present.

ROCK SOLE - AREA 5A - SOUTH QUEEN CHARLOTTE SOUND

Yield Options

The yield options presented here are based on a "short-term" equilibrium situation.

Sustainable Yield Option: A yield of 100 t is considered to be sustainable for the current stock level and low recruitment mode. The 30,000 lb trip limit regulation is consistent with this option.

Non-sustainable Yield Option: Yields of 200 t are considered to be non-sustainable at this time. This is assuming that recruitment to the stock will not increase significantly in the next year.

ROCK SOLE - AREA 5B - NORTH QUEEN CHARLOTTE SOUND

Yield Options

The yield options presented here are based on a "short term" equilibrium situation. Low Risk Sustainable Yield Option: A yield of 200 t is considered to be sustainable for the Area 5B stock. The 30,000 lb trip limit currently in effect for Queen Charlotte Sound is consistent with this option.

High Risk Sustainable Option: Yields of 400 t could be sustained with a significant increase in recruitment. However, the size of the recruiting year-classes cannot be determined at this time.

Non-sustainable Yield Option: Based on trends in CPUE, yields of 500 t can be considered to be non-sustainable for the stock.

ROCK SOLE - AREA 5C - SOUTH HECATE SOUND

Yield Options

The yield options presented here are based on a "short term" equilibrium situation. Low Risk Sustainable Option: The sustainable yield with recruitment at above average levels in the past has ranged between 500 and 1,000 t for the Area 5C stock. A yield of 500 t is equivalent to the average yield sustained during the late 1970s recruitment surge for the stock. A trip limit of 30,000 lbs is consistent with this option.

High Risk Sustainable Option: A yield of 700 t could be sustained if the current recruitment level is mid-way between 1970s and 1960s levels. The exact level of recruitment has not been determined at this time and 700 t can be considered to constitute a high risk for the stock until additional years' data are analyzed.

Non-sustainable Option: Yields of 900 t have not been observed for the Area 5C stock since the mid-late 1960s. The stock size and recruitment at that time were higher than they are currently, based on standardized CPUE and length frequency analysis. Also, the recruiting year-classes have not had time to make a significant reproductive contribution to the stock. This contribution may be important to stability in the long-term for the stock. For these reasons, yields of 900 t are considered to be non-sustainable at this time.

ROCK SOLE - AREA 5D - NORTH HECATE STRAIT

Yield Options

The yield options here are based on a "short term" equilibrium situation. Low Risk Sustainable Yield Options: CPUE increased significantly in 1987. This increase is due, presumably, to an increase in recruitment. Yields of 500-1200 t were sustained in the past, depending on the size and number of recruiting year-classes. Analaysis of standardized length composition indicates that the current recruiting year-class is intermediate in strength to strong year-classes of the 60s and 70s. The 30,000 lb trip regulation currently in effect for rock sole in Hecate Strait is consistent with this option.

High Risk Sustainable Yield Option: If the current level of recruitment is intermediate in strength to that of the 1960s and 1970s, yields of 850 t annually would be sustainable. However, the size of the recruiting year-class(es) cannot be accurately determined at this time. Therefore 850 t is considered to be a high risk for the stock.

Non-sustainable Yield Option: Yields of 1200 t have only occurred in the past when several consecutive strong year-classes have been produced. VPA results suggest excessive exploitation rates in the mid 1960s when removals average 1,200 t. The current stock size is now lower than in the mid 1960s as indicated by CPUE. Therefore, yields of 1,000 t can be considered to be non-sustainable for the Area 5D stock at this time.

ENGLISH SOLE - AREA 5D - NORTH HECATE STRAIT

Yield Options

The yield options presented here are based on a "short term" equilibrium situation. Low Risk Sustainable Yield Option: Yields of 400 t are sustainable with recruitment at low levels. This is based on CPUE trends for the Area 5D English sole stock.

High Risk Sustainable Yield Option: Yields of 600 t have been sustainable with recruitment at average levels in the past and CPUE remained stable with yields at this level. However length composition for the stock indicates some signs of juvenation with removals near this level 3 of the last 4 years. Therefore, the risk of recruitment overfishing for the stock is assumed to be a possibility with yields at this level.

Non-sustainable Yield option: Analysis of CPUE and yield simulations indicate that yields of 800 t are possible for short periods if recruitment is at high levels and age composition for the stock is not truncated. Recruitment is currently not high and indications are that the proportion of older fish in the stock has decreased, at least since the early 1980s. Therefore, yields of 800 t are deemed to be non-sustainable for the Area 5D English sole stock at this time.

DOVER SOLE - AREA 5C/5D/5E - HECATE STRAIT/DIXON ENTRANCE

Yield Options

The yield options presented here are based on a "long term" equilibrium situation. Low Risk Sustainable Option: The analysis above indicates that 800 t yields are sustainable for the Area 5C/D/E Dover sole stock. However, the rising trend in CPUE with removals of 800 t over the last several years indicates that the maximum sustainable yield may well be higher than 800 t.

High Risk Sustainable Option: With effort levels at F opt and CPUE at 1987 levels a catch of 1165 t would be observed. An estimate of 1,000 t is therefore provided as a high risk option for sustainable yield.

SABLEFISH - COASTWIDE

Yield Options

Risk in the yield options below is a function of the uncertainty regarding recruitment. There exists a strong possibility that the high-risk level may interfere with the future yield.

Yield Option 1: Constant Catch

The following options are based on equilibrium runs and are appropriate as a long term average yield.

Sustainable - low risk	- 1,000 t
Sustainable	- 2,600 t
Sustainable - high risk	- 4,500 t

Yield Option 2: Variable Catch

Given a committment to optimizing return from the existing stock, the following levels are appropriate. Again, risk is associated with the uncertainty regarding appropriate recruitment levels.

Sustainable - low risk - 2,800 t
Sustainable - 3,600 t
Sustainable - high risk - 4,400 t

PACIFIC HAKE - AREA 4B - STRAIT OF GEORGIA
(Not including minor Areas 19, 20)

Yield Option

The risk associated with the harvest levels result from the inability to predict the strength of incoming year classes. The three levels of harvest presented are capable of sustaining a spawning stock biomass assuming low, average and high recruitment respectively. Higher risk implies a greater likelihood of depleting the stock below a critical spawner biomass in the event of poor recruitment.

Constant Yield

Low risk sustainable - 8,000 t
Sustainable - 11,000 t
High risk sustainable - 14,000 t

PACIFIC HAKE - AREA 3C - OFFSHORE, SW VANCOUVER ISLAND

Yield Option

The 1989 yield options will be presented at a later date when all of the most current biological information has been collated and incorporated into the assessment.

DOGFISH - COASTWIDE

Yield Option

Possible options include sustained yield, pulse fishing and a variable catch no-nuisance strategy.

A sustained yield fishery will produce oscillations in abundance but they will decrease in amplitude with time. Hence this strategy provides a steady supply while maintaining a stock size lower than present levels. For removals from the offshore stock, including Alaska, British Columbia, Washington, Oregon, and California waters, up to 15,000 t may be considered low risk sustainable and from 15,000 to 25,000 t high risk sustainable assuming an equal sex ratio. If a first and second quarter fishery is to be sustained then yields up to 9,000 t are low risk while 9 to 14 thousand t yields are high risk.

The ranges in levels presented are a reflection of the uncertainty surrounding estimates of starting stock size and the degree of compensatory mortality used in forward simulations. At risk is the collapse of the spawning stock.

Industry has expressed concern over the high abundance of dogfish, which is viewed as a nuisance, and has asked if it is possible to maintain the population at below nuisance levels while continuing to support a directed domestic fishery.

One of the control options proposed is periodic or pulse fishing which is the removal of large quantities of fish at a specific time interval. The biomass of marketable stock is capable of rebuilding to present levels within 3-4 years of removing 30,000 t and within 10 years of removing an unattainable figure of 210,000 t. The large removal, accentuates and perpetuates the pulse in recruitment introduced by the 1940s liver fishery. The extreme variation in abundance resulting from a pulse fishery is further illustrated by a forward simulation of marketable biomass with catches of 60,000 t taken every fifth year. While 60,000 t removals keep the population below the present level for 10 years, over the ensuing 25 years the stock fluctuates to well above present levels and to well below a level where commercial fishing is likely to be viable. The point when fishing is assumed to be non-viable is at, or below, the level of the predicted biomass in 1950. At the end of the liver fishery when, as a result of heavy fishing pressure the abundance decreased to a level where fishing success was poor.

An alternative approach, entitled variable catch/no nuisance option, is to fish intensively for several years until the stock is below nuisance levels and then regulate catch to remove more fish in years when recruitment is high from the liver fishery pulse and vice versa when recruitment is decreasing. Initial catches of 30,000 t for the first four years lower the stock rapidly and catches thereafter ranging from 8,000 to 25,000 t per year maintain a relatively stable stock size.

At current catch rates the trawl effort required to catch the maximum tonnages involved is equivalent to the effort expended in a year by the entire groundfish trawl fleet on all species. One possible way to obtain sufficient effort is to establish a joint venture fishery to remove the difference of the yearly catch that domestic markets cannot utilize.

All options refer to coastwide (including U.S.) removals and no provision has been made for adjusting Canadian catches in the event of increased U.S. catch.

Yield Option 1: Sustained yield, no 1st and 2nd quarter fishery
Low risk <15,000 t
High risk 15-25,000 t

Yield Option 2: Sustained yield - 1st and 2nd quarter fishery only
Low risk <9,000 t
High risk 9-15,000 t

Yield Option 3: Pulse fishing

Yield Option 4: Variable catch/no nuisance

DOGFISH - AREA 4B - STRAIT OF GEORGIA
(Not including minor Areas 19,20)

Yield Option

Dogfish may be harvested on a sustained or periodic fishery basis.

Over the long-term, removals from the Strait of Georgia-Puget Sound stock that are in the range of 4,000 to 6,000 t may be considered low-risk sustainable, while removals in excess of 6,000 t are considered high-risk sustainable. Assuming an even split in biomass between the Strait of Georgia and Puget Sound, 2,000 - 3,000 t is considered low-risk and >3,000 t is considered high-risk for the Strait of Georgia.

Again this range is a reflection of the uncertainty surrounding estimates of starting stock size and the degree of compensatory mortality used in forward simulations.

Yield Option 1: Sustained yield - low-risk - 2,000 - 3,000 t

Yield Option 2: Sustained yield - high-risk - >3,000 t

Yield Option 3: Pulse fishing

Yield Option 4: Variable catch/no nuisance

WALLEYE POLLOCK - AREA 4B - STRAIT OF GEORGIA

Yield Options

The conservative level is based on the lower level of unexploited biomass (25,800 t), a natural mortality of M=0.5, and a constant (a) value of 0.3 for the Gulland equilibrium model calculations from unexploited stock size estimates. The high risk level is based on a midpoint of the biomass estimate (22,600 t), a midpoint in the natural mortality estimate M=0.6 and a constant value of a=0.4 taken as a realistic value for gadid-like species.

Yield options may be choose from:

Yield Option 1: Low risk-sustainable - 2,500 t

Yield Option 2: High risk sustainable - 5,400 t

WALLEYE POLLOCK - AREAS 5C/D/E- HECATE STRAIT

Yield Option

Unrestricted fishery recommended at present.

PACIFIC OCEAN PERCH - AREA 3C - SW VANCOUVER ISLAND
(Including Management Area 125)

Yield Option

The S. alutus stock off southwest Vancouver island remains in poor condition. Equilibrium yield estimates (~70-200 t) remain as calculated in the 1987 assessment. The upper end of this range is probably not sustainable in view of the generally poor recruitment expected over the next 5-8 years. Rehabilitation of this stock to its most productive level should not be expected within the next decade, even with very low fishing mortality, although this process would be enhanced if the 1976 cohort were allowed to contribute maximally to stock biomass and reproduction.

PACIFIC OCEAN PERCH - AREA 3D - NW VANCOUVER ISLAND

Yield Option

The catch history of S. alutus in Area 3D suggests that the historical fishery, although it has been brief, has been able to sustain removals of 250 t/y. The intense S. alutus fisheries of the mid-1960s found no significant quantities of fish in Area 3E, hence the virgin biomass must have been considerably less than those of either Queen Charlotte Sound (~80,000 t) or southwest Vancouver Island (~68,000 t). If the biomass was in the 10,000 - 30,000 t range, then long-term sustainable yield might be 200-600 t.

PACIFIC OCEAN PERCH - AREA 5A - GOOSE ISLAND GULLY

Yield Option

As with all rockfish stocks, the dynamics of the Goose Island Gully stock of *S. alutus* are relatively slow and rehabilitative management actions of even large measure have little impact over the short term. Previous work has shown that, with the exception of complete closure, there are relatively small differences in the periods of rehabilitation between F=0.01-0.05. However, increased yields in the future could be realized if fishing mortality on the stocks was decreased (i.e. F<0.06). The timetable of reconstruction at various levels of fishing mortality has been outlined previously.

While there may be some uncertainty about the exact level of stock biomass in 1988, the values of F associated with long term maximum yield are relatively well determined (F~0.06). Present stock biomass is estimated to be in the range of 8,000-13,000 t, suggested by the simulations using the 1985 and 1977 age compositions, respectively. Yields from these biomasses are dependent on the choice of management policy and have been outlined in previous assessments. For example only, yields at F=0.06 would range, including the contribution of the Mitchell's Gully component of the stock, from ~700-1,000 t. Yields at this level of F are not predicted to produce rehabilitation of the stocks. If management considers maximum available yield and a balanced (1:1) sex ratio to be desirable management goals then a winter fishery, with its female bias, would reduce available yield relative to an unbiased summer fishery.

PACIFIC OCEAN PERCH - AREA 5C - MORESBY GULLY

Yield Options

In 1987, an internal Groundfish Section review of the Moresby Gully *S. alutus* assessment stated that considerably greater yield (3,500 t) than was previously identified (2,000 t) could be taken from the stock. The present assessment indicates that concerns previously expressed about the condition of the stock, on the basis of catch statistics and general life history, should be heeded. While their has been no change in the primary assessment for 1988, the 3,000 t yield is based on the alternative 1987 review. Management is cautioned that the long delay to full recruitment of a cohort renders most measures of stock status insensitive during the early stage (5-10 years) of rockfish fisheries. When declines such as those noted for this stock *are* observed, their import should be even greater.

PACIFIC OCEAN PERCH - AREA 5E-S - WEST QUEEN CHARLOTTE ISLAND

Yield Option

The continued decline of catch in 1987-1988 and the mortality rate estimated by size frequency analysis endorse the concerns previously expressed. A reduction of the estimated yield from this stock is therefore presented for 1989; sustainable yield is estimated to range from 300-500 t.

PACIFIC OCEAN PERCH - AREA 5E-N - WEST QUEEN CHARLOTTE ISLAND

Yield Option

Yields of _S. alutus_ is the order of 2,000 t/y appear to have generated total mortality rates in the 0.6-0.7 range. If these figures are correct, then sustainable yields (Z 0.10) should be in the range of 140-170 t. The upper limits of sustainability are unlikely to be more than twice this figure, and may be less if stock biomass has been reduced below levels giving rise to observed mortality rates. Similar calculations were applied to the average yield of 300 t/y for _S. aleutianus_. Yield options for _S. reedi_ and _S. proriger_ are simply guideline figures base the relationship between initial and long-term yields. Hence, sustainable yields are estimated to be 350-500 t and 500-700 t, respectively. A cautionary note concerning the potential yield from these two species should be added. Both species were recorded by observers in catches by Japanese trawlers during 1977. The exact yields identified here as those of initial fisheries may overestimate long-term yield, when used in this fashion. Characteristics of these two species in this area bear careful scrutiny in the future.

The open-fishery component of this experiment was originally proposed to terminate at the end of 1987 and be followed by a second phase, where the process of stock rebuilding at low or no fishing mortality could be initiated. The results of the second phase will be used to provide guidance on management policies for this and other rockfish stocks. Management chose to continue the open-fishing portion of the experiment in 1988, to provide further evidence of the negative effects of unrestricted fishing. The decline in stock biomass and the deterioration of all stock status indices as a result of the open fishery have been well demonstrated. Incremental scientific benefits from continued open fishing are expected to be very small.

REDSTRIPE ROCKFISH - AREA 3C

Yield Options

The sustainable yield for _S_. _proriger_ in Area 3C is estimated range from 200 - 1,000 t. In the absence of detailed analysis, but recognizing the biological affiliation of the species and rockfish exploitation histories, it would be prudent to maintain yield at ≤500 t for a period sufficient to evaluate its suitability (approximately 5 y).

REDSTRIPE ROCKFISH - AREAS 3D/5A

Yield Option

The yield options for _S_. _proriger_ in Area 3D/5A are based on published work relating initial yields from fisheries to their ultimate long-term yields. These latter yields seldom exceed 200 - 300% of initial yields. The average yield from the first six years of the fishery was approximately 350 t and this may be used as a lower estimate of sustainable yield. The upper limited would then be estimated at approximately 900 t (i.e. 250% of 350 t). Stability of quotas over the next 3 - 5 years may assist in the evaluation of their validity.

REDSTRIPE ROCKFISH - AREAS 5C/5D

Yield Option

Yield from the Moresby Gully stock of _S_. _proriger_ cannot be determined analytically. In the absence of any adverse indications from the limited available data, we assume that the minimum historical landings can be sustained. Indeed, the large stock of _S_. _alutus_ in this area may infer a relatively large stock of _S_. _proriger_, based on analysis of historical patterns of association between these species. The catch proportion ratio from that anlaysis (0.217) implies a yield range of ~350 - 570 T for _S_. _proriger_ in Moresby Gully.

REDSTRIPE ROCKFISH - AREA 5E-S - WEST QUEEN CHARLOTTE ISLAND

Yield Option

In the previous assessment we suggested that the present level landings (~600 t/y) was unlikely to be sustainable. Cluster analysis of landings from this area suggested that the normal catch ratio of S. proriger to S. alutus was 0.217. Based on the yield options identified for S. alutus, the estimated level of sustainable yield for S. proriger is in the 60 - 100 t range. These figures may be conservative if the landing patterns, upon which the catch ratio is based, do not accurately reflect the catch of S. proriger. There has been no evidence they may have been operative in the late 1970s.

YELLOWMOUTH ROCKFISH - AREAS 3D/5A - NW VANCOUVER ISLAND

Yield Option

The stock of S. reedi in the 3D/5A areas has apparently sustained removals of approximately 200 - 250 t/y by the domestic fishery. The previous catch history by foreign vessels is less certain due to species designation problems. While the upper limit of sustainable yield is unknown, at this time it would be prudent to approach the expansion of this fishery in a staged manner. Experience in other rockfish fisheries suggests that yields in excess of 200 - 300% of the initial yields from a fishery are seldom sustainable. Accordingly, the estimated upper limit for the sustainable yield option from this stock is approximately 400 - 750 t.

YELLOWMOUTH ROCKFISH - AREA 5C - MORESBY GULLY

Yield Option

The long-term average harvest from this stock (160 t) is assumed to be a lower limit of sustainable yield. There is little to guide the determination of an upper estimate; we will use the criterion based on initial catches i.e. 200 - 300% of initial harvests represents a non-sustainable level. The upper limit is therefore estimated to be ~500 t.

YELLOWMOUTH ROCKFISH - AREA 5E-S - WEST QUEEN CHARLOTTE ISLAND

Yield Option

Yield options for the S. reedi stock in Area 5E-S remain approximately the same as in 1987, although the range of values reflects the uncertainty associated with this assessment. Sustainable yield is estimated to range from 400 - 700 t.

ROUGHEYE ROCKFISH - AREAS 5E-S - WEST QUEEN CHARLOTTE ISLAND

Yield Option

The estimated yield options for the *S. aleutianus* stock in Area 5E-S reflect the uncertainty of our assessment, although the generally low level of available yield from the area is recognized. Sustainable yield is estimated to range from 200 - 300 t.

YELLOWTAIL ROCKFISH - COASTWIDE

Yield Option

Without consistent trends of declining size or catch rates, there is no sign of growth overfishing; the mean landings for the preceding 20 years, 2,365 t represents a possible minimum estimate of the sustainable yield. We suggest that managers not allow total catch from south and central waters to exceed 4,000 t until a full assessment is conducted. The recommended yield range is 2,000 - 4,000 t.

SILVERGREY ROCKFISH - AREA 3C/3D - WEST VANCOUVER ISLAND

Yield Option

The fishery seems to be focussing on a new pulse of recruitment with no indication yet of whether there are strong year-classes to follow. The 20-year mean harvest of 523 t remains our minimum estimate of sustainable yield. However if catch rates should fall or if the age distribution that is observed in our 1988 survey is more truncated and indicates a higher Z, then we will recommend lower harvests for coming years. Owing to the lower estimates of Z in this assessment, we are less concerned about the stock but still see no evidence to suggest that the stock can support a sustained harvest significantly in excess of historical removals. We recommend a yield range of 400 - 600 t for Area 3C + 3D.

CANARY ROCKFISH - AREA 3C/3D

Yield Option

The continued decline in catch rates is a growing concern and argues whether a yield in excess of the long-term average of 714 t can be sustained. While the changes continue to be viewed as "natural" variation in abundance or availability rather than as evidence for over-exploitation, should the declines continue managers might be advised to consider more conservative yields. A yield of less than two-thirds of the historical yield would be viewed as conservative. Owing to the continued decline in catch rates, the recommended yield range is 500 - 700 t, down from the sum of the Area specific ranges recommended for 1988 of 700 - 1,000 t.

Combined Yield Option for Silvergray and Canary Rockfish for Areas 3C + 3D.

Managers may wish to combine quotas for the two species in Areas 3C + 3D. The annual catch ratio of silvergray to canary rockfish has been 0.87, 1.51 and 1.02 over the last three full years. The ratio of the midpoints of the yield ranges is approximately 0.83.

SILVERGRAY ROCKFISH - AREAS 5A + 5B - QUEEN CHARLOTTE SOUND

Yield Option

The increasing catch rate indicates that the average of annual landings over the last 20 years can be considered a minimum estimate of sustainable yield. Managers may wish to maintain a harvest in excess of the average value of 679 t. We recommend a harvest range of 700 - 1,000 t.

CANARY ROCKFISH - AREAS 5A/5B - QUEEN CHARLOTTE SOUND

Yield Option

The increased catch rate in 1987 is a positive sign but viewed for the present as a short-term increase in availability. The chronically low absolute catch rates (0.25 - 0.44 t/hr) from grounds that have been extensively fished for a variety of species for over 30 years suggests that there is a relatively small biomass, probably not capable of supporting significantly more yield than the historical average of 357 t.

This level continues to be a minimum estimate of sustainable yield. Managers may wish to choose a yield option a modest amount higher. We recommend a yield range of 350 - 500 t.

Combined Yield Option for Silvergray and Canary Rockfish

The catch ratios of silvergray to canary rockfish over the last three years, 2.23, 2.67 and 2.45 have been close to 2.00, the ratio of the midpoints of the recommended yield ranges. A combined quota will probably only result in a slightly higher proportion of silvergray rockfish in the catches than might be desired.

SILVERGRAY ROCKFISH - AREA 5C/5D - HECATE STRAIT

Yield Options

The sustainable yield option was raised from 300 to 600 t in 1983, prior to any effective quota restrictions, under the suspicion that a significant biomass might be present. We suggested that the option be maintained at that level for 3 - 5 years while monitoring for signs of the fishery's impact.

The one sample of older fish tends to contradict the recent decline in catch rate therefore it cannot be demonstrated that the mean harvest of 518 t since 1977 has had a significant impact. We assume therefore that 518 t is a minimum estimate of the sustainable yield. Managers may continue to permit yields significantly in excess of this level, however, the short-term decline in CPUE is a source of concern and because of this the recommended yield range of 400 - 1,000, suggested in the last assessment, is changed to 500 - 800 t.

SILVERGRAY ROCKFISH - AREA 5E - WEST QUEEN CHARLOTTE ISLAND

Yield Option

In spite of the declining catch rates, managers may choose not to impose any landing restrictions. The fishery is largely incidental to slope rockfish fishing, so trip limits will not reduce catches, only increase the amount of discarding. If the trend in catch rates are indicative of a decline in stock biomass, it provides managers with some general insight as to the productivity of this species.

INSHORE ROCKFISH - AREA 4B - STRAIT OF GEORGIA

Yield options for the inshore rockfish assemblage, excluding yelloweye rockfish, are derived from the historical rockfish catch. It is assumed that increments of 25 t are the minimum that can be managed in a statistical area. A 75-t quota is listed as low risk-sustainable for area 12 and sustainable for area 13 because of the depletion that has already occurred in area 13. The option for the other areas is equivalent to the 1986 catch.

The high risk-sustainable option for yelloweye rockfish is based on the 1987 red snapper catch. The 1987 catch is considered risk-sustainable, as the stock currently shows sign of depletion.

Yield option	Other Rockfish			Yelloweye
	Area 12	13	14-20, 28, 29	Area 4B
low risk-sustainable	75 t	50 t	150 t	50 t
sustainable	100 t	75 t	200 t	75 t
risk-sustainable	150 t	100 t	100 t	100 t

These yield options are intended to act as guidelines for managers, and not to imply that management by quota is the best strategy. The winter closure in 1987 was apparently effective in reducing the catch by approximately 25%. There were serious conflicts with the dogfish longline fishery, in that a bycatch of yelloweye rockfish is taken in that fishery.

An alternative to a closure favored by some fishermen is a restricted size range of 1-2.5 lb (0.45-1.14 kg). This is the size range with the highest market value. This range limit would have a major effect in area 13, where the average size of quillback rockfish in the commercial catch is less than 0.5 kg. The minimum size corresponds approximately to the size at 50% maturity for quillback rockfish.

Consideration should also be given to limiting the sport fishery, which accounts for at least 24% of the total rockfish line catch. This may be most important near Campbell River where local closures now apply to the commercial fishery.

INSHORE ROCKFISH - AREAS 3C/3D - WEST VANCOUVER ISLAND

Yield Options

The conservative-sustainable option is the average line catch over the 1956-85 period, prior to the build-up of the fishery. The sustainable option is based on the 1986-87 catch. It is not yet clear whether this level of catch has led to stock depletions. Because of the general uncertainty about appropriate yield levels, the risk-sustainable option is arbitrarily chosen to be 50% above the sustainable level. The yelloweye rockfish share of the quota should be approximately 50%.

Yield Option	Quota (t)
low risk-sustainable	60
sustainable	500
high risk-sustainable	750

These yield options are intended to act as guidelines for managers, and not to imply that management by quota is the best strategy. Future assessments will examine yield levels based on available habitat relative to the Area 4B yield.

INSHORE ROCKFISH - AREAS 5A/B/C/D/E - NORTH COAST

Yield Options

The low risk-sustainable option is the average line catch between 1974-84, prior to the increase in the fishery. The sustainable option is the 1987 catch, as it is not yet clear whether this level of catch has led to serious stock depletions. Because of the general uncertainty about appropriate yield levels, the high risk-sustainable option is arbitrarily chosen to be 50% above the sustainable level. The yelloweye rockfish share of the quota is approximately 50%.

Yield Option	Quota (t)
low risk-sustainable	120
sustainable	580
high risk-sustainable	870

These yield options are intended to act as guidelines for managers, and not to imply that management by quota is the best strategy. Future assessments will examine yield levels based on available habitat relative to the Area 4B yield.

Appendix 1

Table 1. Total Canadian landings[a] (t) of groundfish by species, taken by all gear from all areas on the Pacific coast, 1977-87.

Species	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Mean 1977-86	1987
English sole	1,469	809	1,069	1,244	1,500	559	532	812	692	452	914	755
Rock sole	1,252	1,312	1,874	1,843	1,059	745	668	525	430	454	1,017	887
Petrale sole	289	230	202	222	290	367	439	417	336	416	321	445
Dover sole	700	736	861	1,273	1,245	914	871	1,148	963	1,167	988	633
Rex sole	99	102	203	145	190	74	49	219	205	87	137	83
Starry flounder	89	74	296	118	198	168	66	170	66	54	130	65
Turbot	1,599	2,326	1,826	1,488	946	525	323	369	764	895	1,103	1,193
Other flatfish	15	25	59	57	183	220	199	141	161	215	128	232
Pacific cod	7,717	6,750	9,554	8,703	6,708	4,810	4,505	3,465	2,342	3,650	5,820	13,917
Lingcod	2,248	2,004	2,098	2,151	2,467	4,162	3,755	3,688	5,668	3,827	3,207	3,591
Sablefish	1,088	831	2,031	3,793	3,888	3,976	4,414	3,855	4,275	4,668	3,282	4,719
Pollock	890	2,407	3,387	2,201	1,251	924	1,070	800	1,895	577	1,541	1,270
Hake	2	2	818	606	5,691	2,826	3,122	4,600	6,055	6,802	3,052	13,275
Pacific ocean perch	2,716	3,864	2,819	5,290	5,103	5,983	5,655	6,698	6,069	5,914	5,011	6,335
Other rockfish	5,235	6,608	5,962	4,476	4,857	5,093	7,024	8,512	11,709	19,040	7,852	18,177
Misc. species	289	163	215	303	266	141	156	175	192	245	215	344
Dogfish	1,730	3,126	4,757	4,547	1,151	3,875	3,274	2,510	2,815	3,289	3,108	3,801
Animal food	49	112	214	191	42	65	94	161	309	255	150	188
Reduction	181	302	240	528	302	450	321	244	214	175	296	210
Total	27,657	31,783	38,485	39,139	37,337	35,877	36,537	38,509	45,160	52,182	38,267	70,120

[a] Does not include catches from joint-venture or foreign fishery, see Table 2.

Appendix 1

Table 2. Joint-venture and foreign catches[a] (t) of groundfish from International Area 3C -- southwest coast of Vancouver Island in 1987.

Nation and species	Joint-venture	National	Supplemental	Total
Poland				
Pacific hake	26,347	7,663	2,054	36,064
Walleye pollock	686	19	3	708
Pacific ocean perch	7	65	3	75
Other rockfish	37	159	46	242
Other species	20	3	tr.	23
USSR				
Pacific hake	18,866	11,478	260	30,604
Walleye pollock	325	64	-	389
Pacific ocean perch	1	122	2	125
Other rockfish	70	173	3	246
Other species	tr.	22	-	22
Korea				
Pacific hake	2,863	-	-	2,863
Walleye pollock	71	-	-	71
Pacific ocean perch	-	-	-	-
Other rockfish	5	-	-	5
Other species	-	-	-	-
Total				
Pacific hake	48,076	19,141	2,314	69,531
Walleye pollock	1,082	83	3	1,168
Pacific ocean perch	8	187	5	200
Other rockfish	112	332	49	493
Other species	20	25	tr.	45

[a] Catches (converted from processed weight) are reported by foreign processing vessels and cannot be verified by weight tallies.

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 88-4

BIOLOGICAL ADVICE ON THE MANAGEMENT OF BRITISH COLUMBIA HERRING FOR 1989

At its meeting on September 16, 1988, PSARC reviewed the Herring Subcommittee Report as contained in this document.

The Subcommittee met at the Richmond Inn in Richmond during September 7-8, 1988 to derive a consensus on the status of herring stocks in 1988 and expectations for 1989. The primary objectives for the meeting were:

1. Reach a consensus regarding the status of stocks relative to the 1988/89 fishing season.

2. Review the stock assessment source documents prepared by staff of the herring section and make recommendations regarding 1988/89 catch, for consideration by the PSARC steering committee.

3. Identify areas where further biological research is most needed for management purposes and develop recommendations regarding these problem areas.

The following 8 criteria were evaluated for each stock in order to make recommendations regarding stock status and potential catch levels (Appendix 1):

1. SPAWN AND STOCK TRENDS - Age-structured Model
   - Escapement Model
   - Spawn Indices

2. RECRUITMENT TRENDS - Age-structured Model
   - Escapement Model

3. RECRUITMENT FORCASTS - Analytical models
   - Juvenile surveys

4. FORECAST WEIGHTED RUN SIZE

5. SOUNDING SURVEYS - In-season
   - Winter

6. CUTOFF LEVELS

7. CHARTER SKIPPER COMMENTS

8. ADDITIONAL INFORMATION FOR SPECIFIC STOCKS

Based on the evaluation of these criteria for each stock, conclusions were drawn on the current biological status of the stock and recommendations made as to the potential catch levels for each.

Biological and Management Objectives

British Columbia herring are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level of 25 percent of the long-term average biomass. To ensure conservation of the stocks 20 percent of the forecast biomass of each of seven recognized distinct stocks is harvested annually unless the run falls below the CUTOFF level in which instance the decision may be made to close the fishery to rebuild the stock. The intent of the 20 percent harvest rate is to minimize fluctuations in both catch and spawning biomass. This management policy has been in place since 1983 prior to which the fishery was managed through a fixed escapement policy.

Catch Trends

Herring in British Columbia waters have supported commercial fisheries since 1877. Although catch records date back to 1888, reliable records of place, date, and quantity caught are available only since 1950. There was a fishery for the dry salted market in the Orient from 1904-1934. Up to 85,000 tonnes were taken in a given year. A reduction fishery, mainly by purse seining followed (1935-1967). Fish were taken during their inshore spawning migrations from October to February. Very large catches of over 200,000 tonnes annually in the early 1960s followed by a series of poor recruitments led to the collapse of the reduction fishery, with a closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks. The roe herring fishery began in 1971. Herring are now caught on or near the spawning grounds by both gillnets and purse seines. Roe herring landings have averaged 28,000 tonnes for the last five years.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were given. Roe catches (since 1979; data for 1988 are hailed catches) and quotas (since 1983) in thousands of tonnes are shown below:

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Queen Charlotte Islands										
Roe Catch	8.7	3.4	6.4	5.3	8.1	5.0	6.3	3.6	2.0	0.3**
Roe Quota					*	4.6	5.0	3.8	1.4	0
Prince Rupert District										
Roe Catch	2.5	2.7	1.4	0.1**	0	3.5	6.5	8.3	6.1	8.3
Roe Quota						4.0	5.0	6.4	5.4	7.5
Central Coast										
Roe Catch	0	0.5	2.6	6.3	5.6	7.2	5.2	3.3	3.6	4.5
Roe Quota					*	6.6	4.1	2.3	3.4	3.7
Strait of Georgia										
Roe Catch	6.8	3.3	7.1	8.9	16.4	10.2	6.2	0.2	9.1	7.9
Roe Quota					11.7	11.6	4.7	0	8.1	6.4
West Coast Vancouver Island										
Roe Catch	19.3	4.5	8.8	6.1	8.7	6.7	0.2**	0.2	15.9	9.7
Roe Quota					4.5	4.5	0	0	9.4	8.1
Total Coast										
Roe Catch	37.3	14.4	26.3	26.5	38.8	32.6	24.4	15.6	36.7	30.7
Roe Quota					28.0	31.3	18.8	12.5	27.7	25.8

*North of Cape Caution the quota for 1983 was 11.8.

**Charter boat removals.

Age Composition

Queen Charlotte Islands

There were no fisheries in the area during 1988. The pre-fishery charter samples indicated that the stock was dominated by 3-year old recruits (41.8%) plus a number of 6-and 7-year olds. These are fish from the 1982 (14.1%) and 1981 (17.9%) year-classes. A few older fish, age 10+, primarily from the 1977 year-class (4.1%) were also present.

Prince Rupert District

The seine catch in 1988 was dominated by 3-and 4-year old fish, that is, the 1985 (30.9%) and 1984 (39.0%) year-classes. The 1981 year-class also contributed to the fishery to a lesser extent (11.6%).

Central Coast

The seine catch in 1988 was dominated by the exceptionally strong 1985 recruiting year-class (67.9%). A lesser contribution was made by the 1984 year-class (11.7%). A small number of age 10+ fish (1.2%), from the 1977 year-class, were also present.

Strait of Georgia

North - The charter and fishery samples indicate a good recruitment of 3-year old fish (57.7%) from the 1985 year-class. The 1984 and 1983 year-classes contributed 15.6% and 16.7%, respectively.

South - The catch and charter samples also indicate a good showing of 3-year olds (72.3%) to this area. The 1984 and 1983 year-classes were less evident at 11.1% and 7.0%, respectively.

West Coast Vancouver Island

South - The samples from the 1988 fishery and charter program indicated a good recruitment to the area in the 1985 year-class (60.9%). The 1983 (15.5%) and 1982 (9.2%) year-classes accounted for most of the remaining catch.

North - The 1988 pre-fishery charter samples from this area also reflect a good 1985 year-class (63.7%). Lesser contributions are made by the three preceding year-classes: 1984 - 9.3%; 1983 - 9.2%; 1982 - 13.2%.

Stock Status in 1988

Herring abundance along the British Columbia coast increased in 1988. This increase is the result of very good recruitment to the Central Coast stock and average recruitment levels to the other B.C. herring stocks. The following discussion of stock trends and 1988 spawning biomass is based on the weighted escapement estimates of both assessment models. Stock trends and other assessment criteria are listed in Appendix 1.

North Coast Stocks

The Queen Charlotte Islands and Central Coast stocks had been declining since the early 1980s as the extraordinarily large 1977 year-class moved through the fishery. Both stocks had reached historically high levels during this period and had then steadily declined through 1987. An exceptionally good recruitment to the Central Coast has reversed the trend for this stock. The 3-year old cohort, recruiting to the spawning stock in 1988, appears to be one of the best in the historical time series. The 1988 weighted spawning biomass of 45,400 tonnes represents a 73% increase over the 1987 spawn level.

The 1985 year-class, recruiting to the Queen Charlotte Islands stock as 3-year olds in 1988, is average in size relative to historic recruitment levels. This year-class has halted the steady stock decline in this area and the 1988 estimated spawning biomass of 16,100 tonnes represents a 5% increase over the 1987 spawn level.

The stock in the Prince Rupert District continues to remain near historically high levels. The estimated spawning biomass for 1988 is 36,000 tonnes, a level it has maintained over the past six years. The 1981 and 1984 year-classes which recruited to the fishery in 1984 and 1987, were well above average levels and the 1985 year-class which recruited to the fishery in 1988 was average in size. This succession of good recruitment should maintain the abundance of this stock for a few more years.

SOUTH COAST STOCKS

The two analytical assessment models produce substantially different estimates of 1988 spawning biomass for the two Strait of Georgia herring stocks. Age-structured model analysis suggests an increase in both stocks over 1987 levels, due to above average recruitment in 1988. Spawning biomass estimates obtained from escapement model analysis suggest a slight decrease from 1987 spawn levels for both stocks. For the northern Strait of Georgia stock the difference in spawning estimates from the two models may result from a bias in escapement model estimates. Many spawns in this area were not surveyed until the eggs were close to, or had already hatched, which would lead to underestimation of spawning biomass for the escapement model.

This is not however, the case for spawn surveys in the southern Strait of Georgia. Escapement model estimates suggest a steady decline in spawning biomass since 1979 for this stock. Because this trend warrants some concern for the conservation of this stock the escapement model stock estimates have been given a higher weighting than age-structured model estimates. The weighted spawning biomass estimate for the northern and southern Strait of Georgia stocks in 1988 was 33,600 and 7,200 tonnes, respectively.

Results from both assesment models suggest a slight increase in spawning biomass for the southern west coast of Vancouver Island stock in 1988. The estimate of 28,000 tonnes of spawners represents a 15% increase over 1987 spawn levels. Age-structured model analysis continues to suggest a substantial increase in northern west coast Vancouver Island stocks over the period 1983 to 1988. This trend, and estimates of current spawning biomass, appear high given spawning estimates from diver spawn surveys and in-season hydroacoustic surveys. For this reason, escapement model estimates are weighted higher than age-structured model estimates to obtain one overall stock forecast. The weighted spawning stock estimate for the northern west coast of Vancouver Island in 1988 is 16,600 tonnes, a level similar to that in 1987.

Recruitment Forecasting and Prognosis for 1989

The dynamic nature of herring stocks is a function of recruitment variability. However, because of the many biological and environmental factors involved it is very difficult to estimate recruitment accurately. Ongoing research projects on La Perouse Bank and in Georgia Strait are attempting to elucidate the effects of some of these factors on recruitment.

The potential recruitment to each stock is calculated as the mean of the third best, the middle third, and the third poorest recruitments observed in the historical time series. The expectation for the forecast year is average unless there are other indications that recruitment is expected to be better or worse than usual. However, there is rarely any objective information on recruitment expectations and the actual recruitment level chosen by the subcommittee invariably reflects the expectation for the change in stock status rather than recruitment, per se. This has the effect of moderating the actual harvest rate on particular stocks. For example, if a stock is in decline, the expected recruitment may be changed from average to poor to effect a lower harvest rate and hopefully ameliorate the decline in stock level. The reverse can occur on an upward trend to take advantage of the larger potential catch from a healthy stock.

Recruitments are added to expected return spawners and when the forecast run exceeds the CUTOFF level a 20% harvest rate is recommended. The CUTOFF levels for each stock are established at one-forth of the estimated long term unfished average biomass. CUTOFF levels have been revised this year based on more recent stock productivity parameters. For six areas on the coast, the following CUTOFF levels were established; CUTOFF levels used previously are shown in parenthesis:

	Revised CUTOFF	CUTOFF since 1985
Queen Charlotte Islands	10,600 tonnes	(13,100)
Prince Rupert District	12,100 tonnes	(8,900)
Central Coast	10,600 tonnes	(11,100)
Strait of Georgia	22,100 tonnes	(20,800)
W. C. Vancouver Is. - south	15,100 tonnes	(15,400)
W. C. Vancouver Is. - north	8,700 tonnes	(6,000)

The recruitment assumption, the corresponding 1989 runs, and recommended catches ('000 tonnes) are shown below (also see Appendix 3):

Area	Recruitment	1989 Run	Recommended Catch
Queen Charlotte Islands	poor	13.70	2.74
Prince Rupert District	average-good	42.60	8.52
Central Coast	average	48.50	9.70
Strait of Georgia			
North	average	41.20	8.24
South	poor	8.22	1.64
West Coast Vancouver Island			
South	average-good	36.75	7.35
North	poor	15.80	3.16
Total Coast		206.77	41.35

The forecast stock size for the Queen Charlotte Islands is 13,700 tonnes with an assumption of poor recruitment. While the steady decline in this stock appears to have been halted with an average recruitment in 1988, there is no evidence that the stock has reached a minimum level in the current cycle. Therefore a conservative harvest, based on the stock forecast assuming poor recruitment, is recommended for this area. With this assumption, a catch of 2,740 tonnes is recommended for the Queen Charlotte Islands stock assessment region.

All stock indicators support the analytical model estimates which show that the Prince Rupert District herring stock has been at historically high levels over the past four years. The continued good recruitment to this stock warrants an optimistic forecast for 1989. The forecast 1989 pre-fishery stock, assuming an average to good level of recruitment, is 42,600 tonnes. This yields a recommended catch of 8,520 tonnes for the Prince Rupert District.

For both the Central Coast and northern Strait of Georgia herring stocks an assumption of average recruitment for 1989 was adopted. The forecast pre-fishery biomass for these two stocks is 48,500 and 41,200 tonnes, respectively. The recommended catches are 9,700 tonnes for the Central Coast and 8,240 tonnes for the Strait of Georgia.

Escapement model stock reconstructions indicate a steady decline in spawning biomass for the southern Strait of Georgia herring stock since 1979. This downward trend is consistent with spawn index trends and warrants some concern. For this reason a poor recruitment assumption is adopted for this area. The forecast 1989 pre-fishery stock biomass is 8,220 tonnes yielding a recommended catch of 1,640 tonnes.

Herring stocks on the southern west coast of Vancouver Island supported substantial fisheries in 1988 and the post-fishery escapement estimates are well above the historic mean. An optimistic recruitment assumption of average-good was adopted for this area. The forecast stock is 36,750 tonnes yielding a potential catch of 7,350 tonnes.

Although stock assessment information suggests reasonable stock levels for the northern west coast of Vancouver Island herring stock in 1988 there is concern that fishing opportunities may be limited in 1989, as they were in 1988. For this reason a poor recruitment assumption was adopted. The forecast pre-fishery biomass of 15,800 tonnes yields a recommended catch of 3,160 tonnes for the northern west coast of Vancouver Island.

Fisheries Issues

Currently stock assessments and forecasts are conducted only for the seven major migratory herring stocks. In addition there are numerous minor herring stocks on the British Columbia coast for which there is only limited spawn assessment, catch and biological information. Therefore, it is not possible to do accurate assessments and forecasts for these stocks. In 1988 there was an apparent major increase in the stocks on the west coast of the Queen Charlotte Islands. Stock estimates were 11,700 tonnes from spawn surveys and 10,200 tonnes from pre-fishery charter vessel hydroacoustic surveys. While there appear to be fishery potentials for these stocks, our inability to accurately forecast returns does not permit an objective determination of harvest levels. The Herring Management Working Group will consider options to exploit these stocks outside the current roe-fishery quota system.

Stock assessments are currently conducted for two stocks on the west coast of Vancouver Island with Estevan Point separating the northern and southern stocks. For the 1988 roe-herring fishery there were two licence areas on the west coast of Vancouver Island with Lennard Island separating them. This includes Statistical Area 24 in the northern licence area whereas the stock assessments place this Area in the southern stock. The reason for setting the licence area boundary at Lennard Island was concern that opportunities for seine fisheries would not develop in Area 25. These concerns turned out to be well founded - although substantial quantities of herring were found in Area 25, neither seine nor gillnet fishing opportunities developed in this area and the quota for both gears was taken from Area 24. For 1989 there are again catch quotas for both the northern and southern stocks on the west coast of Vancouver Island. Because fishing opportunities may be limited in the northern stock assessment region fishing plans should allow a flexibility in where the quota is caught.

In 1988 the Queen Charlotte Islands stock assessment region was closed to commercial roe-herring fisheries because the stock forecast of 12,130 tonnes was below the 13,100 tonne CUTOFF level. This past year the CUTOFF levels for all stocks were re-evaluated to incorporate more recent stock productivity parameter estimates. When CUTOFF levels were first introduced in the herring harvesting policy in 1985, they were presented as preliminary estimates. The revised CUTOFF for the Queen Charlotte Islands stock assessment region is 10,600 tonnes, substantially below the initial estimate. The forecast stock biomass of 13,700 tonnes is well above the revised CUTOFF level which will allow a roe-herring fishery in this area. However, had the CUTOFF not been revised this year the area would probably have remained closed to roe-herring fisheries in 1989.

The 9 herring working papers were each reviewed by two people prior to the meeting. The content of each paper is summarized briefly below.

H88-1: This document summarizes stock status for 1988 with forecasts for 1989 based on results from two assessment models for a range of potential recruitments for the seven major migratory B.C. herring stocks.

H88-2: This paper presents estimates of recruitment for five areas of the B.C. Coast based on models developed through time series analysis. Estimates of the tonnage of age 3 recruits are presented in a qualitative sense of poor, average, or good.

H88-3: In response to an industry request to investigate alternate harvest strategies, a simulation study was conducted. This paper examines the effects of higher fixed harvest rates, different CUTOFF levels, variable harvest rates, and differing levels of error in forecast abundance on the long term average catch, variation in the yield, and the probability of certain risks, such as fishery closures, occurring.

H88-4: This document presents some preliminary results from a study designed to investigate the degree of egg loss due to predation undertaken in Barkley Sound during 1988. Estimates of mean egg density are provided at a series of locations through the course of the incubation period along with estimates of eggs consumed by invertebrates, birds, and whales.

H88-5: This document details some results of a hydroacoustic assessment of herring stocks in northern B.C. during the fall of 1987. It provides an independent index of abundance to compare with those from the assessment models.

H88-6: Results of inseason anchor tagging in the Prince Rupert District during 1986 and 1988 are presented. Uncertainty about the relative discreteness of herring schools which spawn in Area 5 and Areas 3/4 pose difficult management problems which this paper tries to address.

H88-7: The paper documents information on age structure of herring on the lower west coast of Vancouver Island which may provide an index of recruitment to this stock. Preliminary indications from two years of data are encouraging.

H88-8: This document presents evidence that the time of peak maturation of female herring may be accurately predicted from a few to several days prior to the event. This has potential application in the staging of roe fisheries in some areas.

H88-9: The paper presents some hypotheses regarding the factors affecting the annual cycle of development and maturation in herring and how these affect spawn timing.

Appendix 1. Criteria used in the assessment of stock status for the Queen Charlotte Islands.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Slight increase in spawning stock.
b) Escapement Model	No change.
c) Spawn Indices	Spawn area up slightly from 1987, and spawn length is down slightly.
2. Recruitment Trends	
a) Age-Structure Model	Recruitment in 1988 is similar to the long-term average.
b) Escapement Model	Recruitment in 1988 is slightly above long-term average.
3. Recruitment Indices	
a) Analytical Models	Ricker-environment model predicts average recruitment.
4. Forecast Weighted Run Size	13,700 t assuming poor recruitment 15,400 t assuming average recruitment 21,900 t assuming good recruitment. A poor recruitment assumption was adopted.
5. Sounding Surveys	
a) Hydroacoustics (winter)	Juan Perez had biomass of 14,620 t
b) In Season	In season estimates were 8,000 t. This is not felt to be accurate as this is difficult area to assess.
6. CUTOFF	Revised CUTOFF of 10,600 t.
7. Charter Skipper Comments	Area 2E stocks didn't look too good.
8. Additional Information	N/A

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the Prince Rupert District stock.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	No change from 1987.
b) Escapement Model	Slight decrease in 1988.
c) Spawn Indices	Spawn length and area down somewhat in 1988, but still close to historic high levels.
2. Recruitment Trends	
a) Age-structure Model	Slight decrease this year, but still above average.
b) Escapement Model	Slight decrease this year, but still above average.
3. Recruitment Indices	
a) Analytical Models	Best model to predict recruitment is long-term average.
4. Forecast Weighted Run Size	34,400 t assuming poor recruitment 37,600 t assuming average recruitment 47,500 t assuming good recruitment An average to good recruitment assumption was adopted for a stock forecast of 42,600 t.
5. Sounding Surveys	
a) Hydroacoustic (winter)	Browning Entrance 11,300 t and Bonilla Island 2,820 t.
b) In Season	Soundings still considered not representative but stocks seem to be the same as last few years.
6. CUTOFF	12,100 t.
7. Charter Skipper Comments	23,000-30,000 t for Prince Rupert District. Area looked good.
8. Additional Information	N/A

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the Central Coast.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Stocks up sharply.
b) Escapement Model	Stocks up sharply.
c) Spawn Indices	Spawn length and area at historically high level.
2. Recruitment Trends	
a) Age-structure Model	Number of recruits up sharply. Near historical high.
b) Escapement Model	Same.
3. Recruitment Indices	
a) Analytical Models	Ricker-environment model predicts average recruitment.
4. Forecast Weighted Run Size	44,700 t assuming poor recruitment 48,500 t assuming average recruitment 58,600 t assuming good recruitment. An average recruitment assumption was adopted.
5. Sounding Surveys	
a) In Season	27,000 t; highest in 1980s
6. CUTOFF	10,600 t.
7. Charter Skipper Comments	Stocks are in good shape.
8. Additional Information	N/A

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the Georgia Strait North stock.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Increase from 1987.
b) Escapement Model	Decrease in 1987.
c) Spawn Indices	Total spawn length is down slightly, but area is the same as in 1987.
2. Recruitment Trends	
a) Age-structure Model	Substantial increase. One of the best on record.
b) Escapement Model	Recruitment in 1988 similar to long-term average.
3. Recruitment Indices	
a) Analytical Models	TFN model predicts average recruitment.
4. Forecast Weighted Run Size	35,600 t assuming poor recruitment 41,200 t assuming average recruitment 50,900 t assuming good recruitment An average recruitment assumption was adopted.
5. Sounding Surveys	
a) In Season	In season sounding for entire Gulf is 38,000 t.
6. CUTOFF	22,100 t for entire Gulf.
7. Charter Skipper Comments	Lambert Channel stocks looked good.
8. Additional Information	There appear to be changes in herring spawning, holding and migration patterns in the Gulf as a whole.

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the Georgia Strait South stock.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Biomass up from 1987.
b) Escapement Model	Continuous down trend since 1979.
c) Spawn Indices	Length is down, but area the same as 1987.
2. Recruitment Trends	
a) Age-structure Model	Estimates good recruitment in 1988.
b) Escapement Model	Slightly below average recruitment.
3. Recruitment Indices	
a) Analytical Models	TFN model predicts average recruitment.
4. Forecast Weighted Run Size.	11,300 t assuming poor recruitment 12,600 t assuming average recruitment 15,900 t assuming good recruitment. A poor recruitment assumption was adopted.
5. Sounding Surveys	
a) Winter	Soundings indicate same stock levels in 1988 as in 1987 for combined Gulf.
b) In Season	In season soundings for entire Gulf is 38,000 t.
6. CUTOFF	22,100 t for entire Gulf.
7. Charter Skipper Comments	Stocks look poor for Georgia Strait South.
8. Additional Information	There appears to be changes in herring spawning, holding and migration patterns in the Gulf as a whole.

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the West Coast of Vancouver Island South stock.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Slight decline in 1988.
b) Escapement Model	Slight increase in 1988.
c) Spawn Indices	Length and area are at historically high levels.
2. Recruitment Trends	
a) Age-structure Model	Above average in 1988.
b) Escapement Model	Recruits up substantially - one of the highest levels on record.
3. Recruitment Indices	
a) Analytical Models	TFN model predicts average recruitment.
b) Juvenile Surveys	LaPerouse Project offshore samples indicate recruitment to be average to slightly above average. However, the temperature relationship would predict below average recruitment.
4. Forecast Weighted Run Size	27,500 t assuming poor recruitment 31,600 t assuming average recruitment 41,700 t assuming good recruitment. An average to good recruitment assumption was adopted for a stock forecast of 36,750 t.
5. Sounding Surveys	
b) In Season	Area 23, 20,500 t Area 24, 12,300 t.
6. CUTOFF	15,100 t.
7. Charter Skipper Comments	Barkley Sound looks very good.
8. Additional Information	N/A

Appendix 1 (cont'd). Criteria used in the assessment of stock status for the West Coast of Vancouver Island North stock.

Criteria	Status
1. Spawn and Stock Trends	
a) Age-structure Model	Biomass up dramatically.
b) Escapement Model	No change.
c) Spawn Indices	Length down slightly, but area is up slightly.
2. Recruitment Trends	
a) Age-structure Model	Number of recruits is up.
b) Escapement Model	Number of recruits is up.
3. Recruitment Indices	
a) Analytical Models	TFN model predicts average recruitment.
4. Forecast Weighted Run Size	15,800 t assuming poor recruitment 18,900 t assuming average recruitment 26,300 t assuming good recruitment. A poor recruitment assumption was adopted.
5. Sounding Surveys	
b) In Season	Area 25, 7,500 t Area 26, 350 t. Area 27, 2,100 t.
6. CUTOFF	8,700 t.
7. Charter Skipper Comments	Possible fishing opportunity off McQuinna Point didn't materialize.
8. Additional Information	N/A

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 88-5

BIOLOGICAL ADVICE ON PACIFIC SALMON

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1. STEERING COMMITTEE REPORT

At its meeting on November 25, 1988, PSARC reviewed the Salmon Subcommittee Report 88-5 as contained in this document. The report summarizes four discussion papers; one concerning management and assessment procedures for coho salmon, and three pretaining to chinook salmon issues in the Pacific Salmon Commission. The Steering Committee approved their report.

The Salmon Subcommittee has evaluated the technical bases to these four topics and presented recommendations on them. The Steering Committee endorses these recommendations but wished to qualify the context of some of these recommendations and to highlight the need for decisions on others.

The Subcommittee has recommended a coho management policy based on limiting exploitation rates on aggregations of coho populations (stock groups), maintaining escapements to certain streams above a minimal level, and in-season abundance monitoring to prevent over-fishing when coho abundance decreases. Subsequently, the Subcommittee recommended a stock monitoring and assessment program to evaluate whether the management objectives were met. The Subcommittee recommended this approach because assessment data is too limited to justify more stock-specific approaches and because of the large mixed-stock fisheries harvesting coho. However, the stock monitoring and assessment recommendations should be considered contingent upon decisions on the management policy and how coho stocks were aggregated for management purposes. The fundamental decisions to be made concerning coho are whether the Department will commit to actively manage coho stocks, and if so, will it adopt the recommended management approach as an interim policy while more accurate data are collected for stock assessments.

Concerning the evaluation procedure for the chinook rebuilding program, the Subcommittee has recommended that doubling the average, aggregate total escapement (for the base years 1979-82) within stock groups continue as the interim Canadian escapement goals for this program. They further recommended that following the attainment of the goals that an evaluation period of approximately eight years be allowed to evaluate the resultant production from the increased number of spawners. Consequently, chinook escapement goals should not be revised in the near term. To evaluate the appropriateness of these goals, however, the Subcommittee recommended allowing escapements to vary about the goal. The Subcommittee also recommended information be collected on age and sex composition of the spawning populations; and that studies are conducted to determine run-timing of spawning populations within stock groups. The latter is needed to evaluate the Subcommittee concern that earlier run-timing chinook are rebuilding more quickly than later timing chinook. If escapement goals to some stock groups are met because of low exploitation on earlier timing portions of the group, we could meet escapement objectives of the rebuilding program without substantially increasing the potential catch.

The Subcommittee recommended excluding the chinook catch in 3 terminal areas of northern B.C. from the chinook catch ceiling of 263,000 chinook established by the Pacific Salmon Treaty. Similar agreements could be made to exclude 3 other terminal areas but more supporting information is required. The proposed exclusion of terminal areas (Skeena, Kitimat Arm, and Bella Coola) would reduce the ceilings to 254,450 chinook.

Gear	Current Ceiling	Proposed Ceiling	Difference
troll	203,000	203,000	0
net	40,000	34,800	5,200
sprot	20,000	16,650	3,350
TOTAL	263,000	254,450	8,550

The difference represents the amount of the original ceiling accounted for by the 3 areas excluded; excluding these areas, so that they can be managed locally, requires that the total northern B.C. ceiling be lowered accordingly. However, it should be noted that the total catch of chinook in northern B.C. will increase substantially because of increased harvest opportunities in these excluded areas. Catches in these excluded areas will continue to be under pass-through obligations of the Treaty and limited by the mixed-species nature of the Skeena fishery, but fishing opportunities on surplus escapement and returns to major hatcheries, at Kitimat and Bella Coola, should increase.

The Subcommittee recommended that chinook production resulting from new enhancement activities (facilities or increased enhancement levels, etc.) be harvested in terminal areas. This recommendation was felt to be the only technically supportable procedure for taking an "add-on" for new chinook production initiatives in Canada. Opportunities for an "add-on" in Canadian troll fisheries are presently limited by the reduced survival, since the brood years in the late 1970's, of our hatchery chinooks. If survivals increased to previous levels then the substantial "add-on's" would likely be available. (The Regional Executive may wish, however, to consider alternative definitions to what constitutes a new source of enhanced production. Other definitions may allow "add-on's" in other fisheries but may not be acceptable in the Pacific Salmon Commission if the impact reduces the rate of chinook rebuilding.) The Subcommittee, also, identified increased contributions of coho salmon from Canadian enhancement facilities. This information should assist in at least maintaining current fishing opportunities in the west coast of Vancouver Island troll fishery (this is the only coho fishery under a catch ceiling).

The Subcommittee also recommended supporting the American proposal to estimate a risk adjustment in determining the catch "add-on". Canada should not accept the American procedure but should evaluate several options for these risk avoidance estimates. This work should be completed before Canada prepares requests for "add-ons". However, if chinook "add-on" is only taken in terminal areas then Canada might simply argue that risk avoidance is unnecessary since we would only be harvesting our own stocks anyhow.

It should also be noted that if new chinook production is to be harvested in terminal areas then the exclusion of some terminal areas in northern B.C. would also allow for increased catch of enhanced chinook in these areas. It would be preferrable to achieve the terminal area exclusions since the requests for and evaluations of "add-ons" would require increased assessment and personnel costs. But, "add-on" is already permissable in the Treaty and will allow for harvest of these fish even if we are unable to re-negotiate the northern B.C. ceilings. However, increased fisheries in terminal areas should be monitored so that Canada can respond to pass-through obligations.

Fishery Impact

The Salmon Subcommittee report indicates several potential impacts on B.C. salmon fisheries. The management policy for coho salmon sets limits to the total exploitation rate on coho. The suggested range of exploitation is between 60-70%, being in the lower portion of the range in northern B.C. Current exploitation rates (1984-86) for hatchery stocks in the Strait of Georgia vary between 70 and 85%, based on coded-wire tagging programs. Consequently, in most years, limits on catch are likely to be needed.

Maintaining the present escapement goals in the chinook rebuilding program will likely allow increased catch of chinook in terminal areas of some stocks that are rebuilding quickly. In northern B.C. these opportunities also require that the terminal areas of interest be excluded from the present all gear catch ceiling. However, if we are not successful in excluding these areas then hatchery "add-ons" could be used to permit increased terminal catch in statistical Areas 6 (Kitimat) and 8 (Bella Coola). If a terminal exclusion for the Skeena River is not achieved then difficult decisions must be made concerning the incidental catch of chinook during sockeye and pink net fisheries. Possible actions include:

- limiting sockeye and pink fishing times to reduce the chinook catch;

- re-allocate chinook from the northern B.C. troll and/or sport fisheries to allow increased chinook during the normal execution of these net fisheries; or
- impose chinook non-retention in nets when a certain catch of chinook is estimated.

The latter would of course be wasteful and would probably still impose an added cost because it would be considered a new source of induced mortality. Obviously, a high priority should be placed on negotiating these terminal area exclusions.

In the past few years Canadian hatchery coho have contributed substantially more fish to the west coast of Vancouver Island troll fishery. While the provision of "add-ons" for coho salmon is not explicity included in the Pacific Salmon Treaty, this information can be used when re-negotiating the catch ceiling for the west coast troll fishery. The Americans are likely to push for a lower ceiling. The re-negotiated ceiling should, however, credit Canada for this increased production from Canadian enhancement.

II. SUBCOMMITTEE REPORT

INTRODUCTION

The Salmon Subcommittee met at 555 West Hastings, Vancouver, B.C. on November 14 - 15, 1988. The committee considered 4 Working Papers. Priorities for these working papers were established by Regional senior management. Two working papers requested by senior management for this fall have not been completed. These papers were to address the rebuilding status of chinook salmon in the transboundary rivers of northern British Columbia, and a documentation of the rebuilding plan established for chinook salmon in the lower Strait of Georgia. Preparation of these documents is continuing and will be reviewed by the committee later this fall; to be available for the February meetings of the Pacific Salmon Commission.

The objectives for this meeting were to:

1) Review discussion papers needed to advise on technical issues expected in the 1988 Pacific Salmon Commision negotiations;

2) Develop consensus on advice and recommendations from papers presented; and

3) Review assignments for March 1989 sub-committee meeting.

This report provides a synopsis of the working papers, and the sub-committee's advice and recommendations.

1. Stock Monitoring and Assessment Requirements for Coho Salmon Stocks in British Columbia (PSARC Working Paper S88-22):

Coho salmon stock assessments have been the subject of three previous PSARC advisory documents. Each of these documents recognized coho conservation concerns, and recommended that improvements are needed in our stock assessment capability. At present, our assessment capabilities are severely limited. Coho salmon are produced in over a thousand streams and rivers in British Columbia, catch by stock is unknown, and escapement data are inaccurate and inconsistently collected. Further, since there are no explicit management objectives for the vast majority of B.C. coho stocks, monitoring programs have been difficult to develop, many coho fisheries have continued to expand, and coho conservation concerns in several areas, notably the upper Skeena River, Georgia Strait and the lower Fraser River, have not been addressed. This working paper recommends a management policy for coho salmon and monitoring programs which would be needed to implement this policy.

A practical management policy for coho salmon must recognize the limitations to our existing data and understanding of coho stock dynamics (i.e. productivity, ocean distribution and survival), and be sufficiently flexible to adjust for conservation concerns and/or improved understanding of coho stock dynamics and management systems. The capacity of four management approaches to meet these attributes were examined to determine the best approach for B.C. coho stocks:

1) Maximum sustained yield (MSY) escapement - achieve the escapement that is estimated to provide maximum return rates per spawner. Although this is the objective for most actively managed sockeye, pink and chum stocks, the mixed-stock nature of most coho directed fisheries and the lack of necessary stock-specific data precludes this approach for most coho stocks at this time. Further, evaluations would focus on escapements which are notoriously difficult to collect accurately.

2) Escapement range - remain within a range of escapement within which MSY escapement is believed to exist. As with the MSY escapement approach, the conduct of our coho directed fisheries does not allow for the precise in-season adjustments in harvest required by this approach; and evaluation again focuses on escapement data.

3) MSY exploitation rate - harvest coho at an exploitation rate which should on average produce MSY. Knowledge of catch distribution and historical exploitation rates can be used to design fishing plans which will on average produce a targeted exploitation rate. This approach presumes that some coho stocks have been tagged so that exploitation histories are available. Further, if catch ceilings are used to limit exploitation then estimates of coho abundance must be available to prevent over-fishing at low abundances.

4) MSY exploitation rate with an escapement floor - this approach uses an MSY exploitation rate in combination with a minimum escapement level (i.e. a floor) to protect against stock collapse in years of extremely low abundance.

In addition to items in (3) above, a pre-season or early in-season estimate of abundance and contingency management measures are required for this approach to be effective.

Given the necessity to harvest much of our coho resource in off-shore mixed-stock fisheries and the resulting impracticality of estimating catch by stock, the only practical approach to managing and assessing coho seems to be via exploitation rate. Exploitation rates may be determined by tagging and achieved by limiting fishing effort, but stock and fishery evaluations both require accurate and consistent monitoring of escapements, at least in some stocks assumed to be representative of coho production in an area. To reduce the problem of the number of coho populations, it is convenient to aggregate coho stocks into groups based on region of origin, vulnerability to major ocean fisheries, productivity, and other factors. Within each stock group two types of monitoring programs would be conducted: intensive programs (key streams) to provide information on accurate escapements, ocean distribution, exploitation, and productivity; and, more qualitative and extensive programs (index stocks) to monitor escapements over a range of stocks within each group to ensure that key streams were adequately representing the stock group.

SUBCOMMITTEE ADVICE

Management and Fishery Assessment

Management objectives and active management of coho resources must be established in British Columbia. The Committee recognized that the information base for establishing objectives is poor but also noted that to acquire better data will required several more years. In the interim, our recommendation is to adopt a management policy based on exploitation rates, plus establishment of minimum escapement levels to certain "key" indicator stocks, and studies to develop index measures of ocean abundance of coho salmon. The development of these abundance indices are essential if protection is to be provided when abundances of coho decrease or distribution shifts. Further, since coho are usually fished in their year of maturity, particularly coho in southern B.C., the fisheries must be adjusted within that year to conserve coho from one brood year. Specifically, the committee recommends:

1) if management to an escapement objective (for example, a test fishery index) is infeasible, establish target ranges for exploitation rates between 65 to 70 percent and 60 to 65 percent for south coast and north coast coho stocks respectively. For north coast stocks a lower range of exploitation is recommended based on a stock assessment of the Skeena River coho and a general belief that more northern stocks are less productive than southern stocks. These exploitation rate targets may be adjusted in future based on analyses of stock recruit data collected in key stream monitoring studies. Adjustments are not anticipated until a minimum of at least ten years of data are collected.

NOTE: Current exploitation rates (1984 to 1986) for hatchery stocks within the Strait of Georgia indicate that exploitation rates presently range between

70 and 85 percent. Consequently, in some years, significant catch limitations would be necessitated.

2) establishment of escapement floors to protect against escapement over-fishing when ocean abundance of coho is depressed. Floors would be developed for populations in which we have some information on desired escapement ranges. This approach will require that the management system implemented be flexible to allow for in-season adjustments in fishing plans to all major fisheries if abundance is lower than some, as yet unidentified, threshold level.

3) development of coho abundance indices, by examining historical data and:

   a) monitoring catch and effort levels in major fisheries to examine relationships between fishery parameters and stock abundance;

   b) investigating the feasibility of early season test fisheries in priority areas as means of monitoring coho abundance;

   c) development of pre-season forecasts of abundance and distribution (while not critical for program success, this can facilitate pre-season fishery planning and interpretation of other monitoring data).

Stock Monitoring and Assessment

To fully implement the above management policy, the committee recommends the following:

1) for assessment and management purposes coho populations should be aggregated into stock groups based on geographic proximinity, similarities in catch distribution, and any available data on habitat quality and productivity;

2) that intensive studies be undertaken on at least a few key streams in priority areas. These programs must estimate ocean distribution, exploitation rates and evaluate stock productivity (while these programs are expensive and difficult to undertake, modification of initial exploitation rate target ranges and escapement floor levels will only result from these intensive studies);

3) that in areas where intensive studies are not being conducted and to complement the "key" stream studies, that qualitative escapement surveys based on index stocks in a larger number of streams be implemented. The current fishery officer escapement program may fill this need with some improvements. Specifically:

   a) the historical escapement record as reported by fishery officers should be evaluated for consistency and reliability, and the best data extracted for escapement trend analysis.

b) where practical, escapement survey methodology should be standardized to improve current estimates. The number of streams surveyed should not be allowed to deteriorate without a technical review to ensure that counts on index streams are maintained.

c) test fishery programs on the Fraser and Skeena rivers should be maintained and improved where possible to better evaluate coho returns to those rivers.

d) in a subset of streams, research aimed at assessing different escapement indexing methods (live counts, dead counts, peak live plus accumulated dead counts) should be pursued with the objective of providing future guidance regarding the design, execution and standardization of indexing methods.

4) that the stock groups, once defined, be prioritized as to where resources for key streams should be directed. It is unlikely that enough resources will be available to address every geographic area (prioritization might be based on conservation concerns, expected expansions of fishery impacts, and international treaty concerns);

5) that coded-wire tag programs be examained for:

a) effects of the coded-wire tagging on ocean distribution, survival and exploitation; and,

b) ensuring that estimates of exploitation rate are not biased by straying, missed marks, etc.

This recommended assessment procedure is similar to the existing chinook programs. The aggregation of coho populations into larger stock groups may result in similar concerns as discussed in working paper S88-23 for chinook salmon. However, until more detailed information is available for coho salmon, these concerns can not be assessed.

2. Discussion Paper on the Evaluation of Chinook Rebuilding (Working Paper S88-23):

The "Chinook Rebuilding Program" is a coastwide initiative, formalized within the Pacific Salmon Treaty, to restore production of chinook salmon. Previous to the Treaty, both the United States and Canada had recognized the need to increase spawning escapements through reduced exploitation rates. However, because of the northward migration of chinook neither country could control the total exploitation on their stocks due to catches in the other country. Consequently, a joint program to restore production from naturally spawning chinook stocks was agreed to within the Salmon Treaty. Once the stocks have been rebuilt, Canada and the United States agreed to establish fishery regimes to maintain the stocks at optimum production, to share the increased production, and to provide fair domestic allocation of the benefits. However, it has become obvious that all chinook stocks will not rebuild at the same rate. Consequently, when the two countries can begin sharing the increased production, depends on the evaluation criteria set for the rebuilding program. This paper outlined rebuilding obligations under the Treaty, reviews the establishment of Canadian escapement goals for chinook salmon, and presents options for criteria to evaluate the rebuilding program.

Treaty Obligations

Paragraph 1a. of Chapter 3, Annex IV of the Pacific Salmon Treaty:

1. Considering the escapements of many naturally spawning chinook stocks originating from the Columbia River northward to southeastern Alaska have declined in recent years and are now substantially below goals set to achieve maximum sustainable yields, and recognizing the desirability of stabilizing trends in escapements and rebuilding stocks of naturally spawning chinook salmon, the Parties shall:

   a) instruct their respective management agencies to establish a chinook salmon management program designed to meet the following objectives:
      (i) halt the decline in spawning escapements in depressed chinook salmon stocks; and,
      (ii) attain by 1998, escapement goals established in order to restore production of naturally spawning chinook stocks, as represented by indicator stocks identified by the Parties, based on a rebuilding program begun in 1984."

To summarize this statement, our obligation is to achieve escapement goals by 1998 in a subset of stocks, selected as indicators of naturally spawning chinook stocks, to increase the production of chinook salmon. These goals are assumed to be set to achieve maximum sustainable yield but the goals of the rebuilding program are to be identified by each country.

Escapement Objectives for B.C. Chinook Stocks

All escapement goals for B.C. chinook stocks are presently set by a policy objective to double the average escapement observed between 1979 and 1982. This objective was set in early 1983 following a Regional workshop in 1982 to review two stock-recruitment analyses of B.C. chinook production, and to recommend how to resolve the differences in optimum escapements suggested by these two analyses. The conclusions of these analyses and the workshop were that chinook stocks were being over-harvested, that escapements were declining continuously, and that optimum escapements were above recent escapement levels. However, due to the numerous assumptions involved in the stock-recruitment analyses, optimum escapement goals were highly uncertain. Doubling a recent average escapement was recommended because:

- doubling the 1979-82 average escapement was within the range of optimum escapement estimates from both stock-recruitment analyses;
- one of the analyses suggested that chinook may have only recently become over-exploited (i.e. in the late 1970s);

- a doubling of escapements was felt to be a large enough change in escapements that the resulting production could be evaluated given the existing catch and escapement monitoring programs.

Unfortunately, there were no recommendations on how the doubling would be implemented or evaluated. The participants assumed that all stocks would respond positively from this initiative but did not necessarily assume that all spawning populations would double due to variation in productivity. On average, however, total chinook escapements should double.

Escapement Goals for B.C. Chinook Stocks

With the implementation of the Treaty, the doubling policy was applied to aggregate escapements within broadly defined stock groups (for example, the Skeena River, Upper Fraser River, Upper Georgia Strait, etc.). The exception to the aggregation of populations is the Harrison River stock in the lower Fraser River. In each stock group the escapement goal is for the aggregate escapement over all the spawning populations within the group, and calculated as double the 1979-82 average annual total escapement. The application of the doubling policy across aggregated populations is consistent with the original stock-recruitment analyses, assuming that reductions in harvest rates occur across all populations within each group. Canadian members of the Pacific Salmon Commission's Chinook Technical Committee have qualified these goals as interim target goals which may be revised after more information is collected.

However, since 1984, substantial variation has been observed in the rate of increase in spawning escapements amongst individual populations in a stock group, apparently depending upon the migration timing of the populations. Differential exploitation rates between stocks negates the assumption (above) involved in applying doubling to stock groups. If escapement goals for the aggregate stock remain the doubling of the aggregate total, we may not meet the obligation to increase production since most of the total spawning stock may be from populations that contribute very little to the catch. Consequently, any subsequent stock-recruitment analysis would indicate that the stock group has low productivity; when in actuality the stock group is composed of several stocks some of which are under-utilized and some of which are over-exploited.

Issues Involved in Evaluating Rebuilding

1) Have we stopped the decline in escapement to each stock?
2) How will we measure doubling in the stock groups?
3) How consistently must we meet our rebuilding goals before accepting that the stock is rebuilt?
4) Do we only have to meet our escapement goals or do we also have to demonstrate increased production?
5) Canadian goals have always been described as interim targets, how will we evaluate the appropriateness of our goals and what procedure will be established to alter these goals?

Since each country can set their own rebuilding objectives in terms of escapements goals and indicator stocks, we have a number of options as to how we resolve these issues.

Issues 1 and 2 involved the same evaluation problems, for example, has the total escapement increased or decreased versus have all escapements increased or are some still decreasing? The understanding of the fishing industry when they agreed to the Rebuilding Program is that they agreed to double the aggregate totals within stock groups. However, given the observed differential response of populations within these groups, this is probably no longer an acceptable goal from a stock assessment perspective. Other options include:

- doubling each individual spawning population;
- doubling some minimum percentage of the populations;
- doubling the average multiple increase across all populations;
- doubling a set of indicator stocks (either selected as a random sample or more specific criteria);
- redefining the stock groups by river and run timing and double the total escapement within these revised groups.

Issue 3 results from the objective to stabilize escapements. Stabilization involves two criterias: how consistently the goal is achieved, and how variable the escapements are about the goal. If consistency was evaluated as how often we meet the goals without regard to how variable escapements are, then we are not likely to maximize production. Options for evaluating stability include:

- achieving the goal at some percentage of the time (for example: 100%, 4 out of 5 years, etc.);
- using a moving average to estimate escapement trends.

The latter option has the advantage of not establishing a rigid criterion when background environmental variation may preclude achieving the criterion.

Issue 4 developed because the Treaty obligation may be interpreted as only having to achieve the escapement goal by 1998. However, achievement of escapement goals by 1998 under the present catch ceilings assumed that increases in escapements would result in increased production. The increased production would increase ocean abundance of chinook and, under catch ceilings, result in the continuous decline of ocean exploitation rates. But if the goals were not appropriately set and increased production did not result, then the catch ceilings would not be effective in reducing exploitation rates and some goals would not be met. There does not seem to be an option here; production responses from increased escapements must be realized and evaluated to monitor productivity of the chinook stocks. The production response may be evaluated by stock identification programs or by monitoring brood year exploitation rates through coded-wire tagging. The latter method is currently available and is in use now.

Canadian escapement goals are interim targets and are expected to be refined as more information becomes available (Issue 5). The rebuilding evaluation procedure must allow for monitoring of production responses from increased escapements and age composition in catch and escapement. Consequently, once escapement goals have been met, the production response from several brood years at or above the goal should be monitored before the goals are changed. Once the interim goal is met, approximately 8 years of evaluation will be required before a goal can be assessed quantitatively. However, evaluation of the appropriateness of the goals may be enhanced by allowing escapements to vary about the goal, by:

- stepwise increments in the goal;
- maintaining the goal but allowing a fixed harvest rate on terminal returns in excess of the goal;
- maintain the goal as an objective but allow fisheries to operate on a fixed harvest rate or effort schedule, thereby, allowing escapements to vary with chinook abundance.

The latter two options would allow the industry to increase catch while higher levels of escapement are investigated. These approaches would be cooperative ventures with the industry.

Sub-committee Advice

Consensus within the committee was only reached on:

- that, at this time, rebuilding should be evaluated based on doubling the aggregate total escapement within each stock group;

- that an evaluation period following the achievement of escapement goals is essential to evaluate the resultant production from these increased escapements, consequently, in the near term, escapement goals should not be adjusted;

- that age and sex composition must be collected in our biological sampling programs of catch and escapements; and,

- that escapement goals should be refined to finer levels of resolution (i.e. by river and run timing) when more information is available.

The committee acknowledged that the differential increases in escapements within stock groups may well indicate that separate stocks exist within these aggregates. However, most members were not prepared to sub-divide the stock groups because they did not believe that information on run timing differences between spawning populations was adequate to support this division. If rebuilding is to be evaluated on the basis of the aggregate total escapement and resultant production, careful monitoring of the variability of escapement responses between populations must be undertaken to interpret the production response. Further, the committee recommends that studies to determine the run timing of populations into our major chinook producing rivers be undertaken.

The committee did not reach consensus on how consistently escapement goals must be achieved, or how to evaluate consistency. This issue becomes intertwined in how to evaluate the appropriateness of the established goals. We may deliberately allow the escapement to vary about the goal to evaluate what the optimum escapement should be. In evaluating the goal the committee recommends:

- that increased production be shared between catch and escapement based on a harvest rate sharing arrangement with the user groups;
- that the present goals should be checked to evaluate whether recent enumeration programs (i.e. increased effort by enhancement staff, increased attention to chinook monitoring because of increased conservation awareness, etc.) are consistent with previous data collection practices; and
- that the programs to be used to evaluate the production response from rebuilding be reviewed to ensure that we will be able to reliably evaluate the response.

3. A Discussion Paper on Exclusion of Terminal Catches in North Coast Chinook Fisheries (Working Paper S88-24).

When the Pacific Salmon Commission established catch ceilings for chinook in 1985, the gear types included under the catch ceilings differed between management regions. In southern British Columbia, only the ocean sport and troll fisheries were included in the Strait of Georgia and only the troll fishery was included on the west coast of Vancouver Island. But, in northern British Columbia (defined as the entire coast north of Vancouver Island) and in S.E. Alaska most sport, net and troll fisheries were included under one total catch ceiling. In the anaylses which led to the establishment of the ceilings, however, all management regions were treated the same: sport and troll fisheries (hook and line fisheries) were put under ceiling management while nets received an overall 25% reduction in harvest rate but were not under a catch ceiling. Catches in the net fisheries varied depending on the abundance of fish available. During these analyses, sport catches in S.E. Alaska, North B.C., and the west coast of Vancouver Island were assumed to be relatively insignificant in the overall assessment or were lumped with the troll catch.

The decision to include or exclude catches from a particular gear type or fishery in the negotiated ceilings was a combination of biological assessment and political necessity. The purpose of this discussion paper is to provide a rationale for excluding certain specific terminal catches from the ceiling in northern B.C. In this paper, a "terminal area" is defined as an area where catches are presumed to be made up to a very large extent of stocks from the most adjacent river. Systematic tagging data are rarely available for chinook in these specific areas, so there is usually little supporting information to establish the stock composition of the total catch.

Rationale

The reason for excluding the catches in terminal areas from the areas from the northern B.C. ceiling is the expectation that catches in these areas will begin to increase substantially as stocks rebuild. Chinook catches in these areas are usually due to incidental catches during net fisheries directed on sockeye, pink, and chum salmon. If these fisheries remain under catch ceiling management, then chinook will have to be reallocated from other gear types to offset the rise in terminal area catches, or the directed fisheries will be limited by the chinook ceiling, or chinook may be discarded during net fisheries in these terminal areas. It is the premise of this discussion paper that these options are either unfair to the other gear types, or inefficient resource uses, or unnecessary for the following reasons:

1. Nets catch were not limited by ceilings in the original assessment that led to the establishment of the ceilings. Instead a blanket 25% reduction in harvest rate was applied. The model predicted rebuilding would occur in spite of the fact that the net catches were allowed to rise as terminal run sizes increased.
2. Most northern rivers are exceeding rebuilding expectations. Rebuilding rates relative to the 1998 goal would not be compromised by removing these fisheries from ceiling management.
3. Hatchery programs in some of these areas are just coming on-line. Opportunities to harvest the surplus returns should be provided so that Canada receives benefits from this new production.

Areas to be Considered for Exclusion

Table 1 lists the areas where net fisheries are currently taking place in northern B.C. or where hatchery programs are expected to generate terminal fisheries in the future. The following were considered for exclusion from ceiling management:

1. Nass terminal management units (3-7 to 3-17).
2. Skeena terminal area (Management Unit 4-15 and inner parts of 4-12, known as "River/Gap/Slough").
3. Kitimat terminal areas (at head of Douglas and Gardiner channels). This is primarily a sport fishery but may include terminal gillnet fisheries at some future date.
4. Bella Coola terminal areas (Management Units 8-10 to 8-12 and 8-15).
5. "Terminal" fisheries currently taking place in statistical Areas 9 and 10 (Rivers and Smith Inlets).

Methods

Calculation of ceiling adjustments depends on catch data from two sources: the Salmon Stock Assessment (SSA) catch data base (historical commercial catch data, Pacific Biological Station, Nanaimo, B.C.), and unpublished data from the North Coast Division of Fisheries Branch (Prince Rupert, B.C.). The North Coast Division provided:

a) a "hail" catch data base of in-season catch estimates for terminal areas; sub-area resolution of catch is not maintained in the SSA catch data base, and;

b) sport catch estimates by statistical area.

To estimate the reported catch in the terminal areas these data sources were combined by:

1. "Hail" data are summed for both the terminal area in question and for the total statistical area. The fraction that is represented by the terminal area is calculated and then applied to the catch from the same statistical area in the SSA data base.

2. The sport catch data are used without adjustment to calculate the relative proportion each area represents of the total northern B.C. sport catch.

In determining how many chinook would be removed from the catch ceiling to adjust for the exclusion of terminal catches, catches for the terminal areas were calculated for the base period 1979-82.

Coded-wire tag recovery data were obtained from the Mark-Recovery data base also maintained at the Pacific Biological Station.

Presentation of Terminal Areas to be Excluded

The recalculations of the northern B.C. chinook catch ceiling are presented in Tables 2 and 3 of the Working Paper S88-24. In the following discussions, it is assumed that the current northern B.C. catch ceilings are:

1.	203,000	for troll;
2.	40,000	for all nets (excluding the catch of under 5 lb. fish which are usually referred to as "jacks"); and,
3.	20,000	for sport.
Total	263,000	for all gear (before adjustments for over-ages)

Nass

At present, the fishery that would be excluded is a terminal gillnet that may occur in various portions of the defined terminal area depending upon management objectives. This river supports a large chinook run and the expectation is for substantial production increases from the rebuilding program. Chinook in this river appear to be responding to the current rebuilding program but their rebuilding progress to-date is not as clear as in the other northern B.C. rivers. There are no large scale hatcheries for chinook in this system.

This area is poorly defined in terms of historical catch data, even though a terminal area (3Z) is identified in the historical catch data. The definition of this area has not always been consistent when catches have been allocated to area. This has been even true of the "hail" catch data being collected by DFO field personnel. The average base period catch in this area was only 2,800 chinook (excluding jacks) and current catches are under 1,000 fish. Therefore, the share of this fishery in the northern B.C. catch ceiling is small (about 1,600 fish). Stock composition of chinook in these management units is unknown since no coded-wire tags have been recovered specific to these management units. However, it is expected that in the more outside areas (Management Unit 3-7), the chinook catch is not comprised only of Nass River chinook, particularly in fisheries occurring from July onward. Due to the uncertainty of the stock composition of chinook in this terminal area, particularly in Unit 3-7, the Sub-committee did not support exclusion of this area.

Skeena

At present, the fishery under consideration is a terminal gillnet fishery that takes place immediately in front of the mouth of this river. The Skeena supports the largest chinook run in the northern B.C. and the expectation is for substantial production increases from the rebuilding program. Many of the stocks in this river, especially those with return timings prior to the sockeye fishery, appear to be responding well to the rebuilding program. There are no large scale hatcheries for chinook in this system, but there are a few small facilities.

Catch data from the defined terminal area are not available prior to 1984. Since then, gillnet catches have averaged about 4,500 (excluding jacks, 1984 to 1987 average), which represents about 55% of the gillnet catch in Area 4. This percentage was applied to base period catches to establish the size of the ceiling reduction. Consequently, the allocation of the catch ceiling to this fishery is 2,400 fish (rounded to the nearest hundred fish). Stock composition within these management units is unknown but expected to be almost completely Skeena River chinook since the areas are in the mouth of the Skeena River.

Kitimat (Management Unit 6-1)

This terminal area is a long inlet, Kitimat Arm, and is the site of one of two large chinook enhancement facilities in northern British Columbia. In recent years, a large sport fishery targeting on the returns to the Kitimat hatchery has developed. Compilation of raw tag data from heads turned in at this hatchery shows that in most years over 2/3 of the tags from the Area 6 sport catch originated from the Central B.C. enhancement facilities. In addition, all ages are represented in the recoveries. Considering the small number of Central Coast tags released this should indicate that local stocks are the primary contributors to this fishery. In addition, escapement estimates from this statistical area are increasing at a rate above the rebuilding schedule.

The Area 6 sport fishery represented from about 20% to above 50% of total northern B.C. sport catch of chinook for the period 1977 to 1987. However, the average is about 25% between 1983 and 1987. In earlier years, this fishery took large numbers of small fish (largely progeny from the hatchery judging from the tag returns). Since 1982, when the coastwide sport size limit was increased from 30 cm to 48 cm, the proportion of the total sport catch account for by this fishery has declined. Further, the area to be excluded is only the upper portion of statistical Area 6. Sport catch in management unit 6-1 accounts for approximately two-thirds of the total Area 6 sport catch. Therefore, the portion of the ceiling to be removed, if this fishery is excluded, would be 3,350 using information for the more recent time periods (i.e. 67% * 25% * 20,000).

Bella Coola

At present, this is another terminal gillnet fishery occurring a long distance up a narrow inlet. The Bella Coola River is also the site of the other large chinook enhancement facility in northern B.C. In addition, the Atnarko River, a tributary of the Bella Colla, supports a large natural chinook run. This chinook stock is responding well to the rebuilding program.

Hail catch data for this area have been collected routinely since the base period. The base period average catch in this fishery was 5,000 fish. More recent catches, because of closure of the directed chinook fishery, have averaged well under 1,000 fish. Again the stock composition in this specific area is unknown but is presumed to be largely local stock due to the distance up the inlet, particularly for large chinook caught early in the summer. The allocation in the net catch ceiling for this fishery is 2,800 fish (rounded to the nearest 100 fish).

Rivers and Smith Inlets

Terminal gillnet fisheries for sockeye occur in these inlets. As well, there is an important sport fishery in Rivers Inlet. However, examination of coded-wire tag data shows that chinook from other areas are taken in these fisheries, particularly at young ages. Therefore, the terminal gillnet fisheries in these areas are probably not good candidates for terminal exclusion. This may be due to the fact that the gillnets fish near the entrance of the inlets where substantial mixing with other stocks can occur.

The sport fishery in Rivers Inlet is probably also taking a mixture of stocks, especially among the smaller fish. Most of the largest fish probably belong to local stocks (Rivers Inlet is famous among sportsmen for the large size of fish in the returning run) but coded-wire tag recoveries for older fish (5 and 6 year olds) do demonstrate that other stocks are also contributing large chinook to this fishery. However, the numbers involved are relatively small and the adjustment to the ceiling would only be about 1,000 fish. The local stocks appear to be ahead of the rebuilding schedule and some small scale enhancement is beginning in the area. Therefore, this fishery could be a future candidate for terminal exclusion. This would require careful monitoring of the the stock composition of the catch, particularly by size category.

The status of the Smiths Inlet chinook stock is uncertain, and it has not responded to rebuilding as clearly as other northern chinook stocks. Therefore, fisheries in this inlet should probably not be considered as candidates for terminal exclusion at this time.

Discussion

Removing some terminal fisheries from the northern B.C. catch ceiling does not mean that management of the stocks involved will cease. These fisheries will still be under the pass-through obligations of the Salmon Treaty. As well, mixed-species harvest problems and allocation of terminal runs between user groups will likely limit the catch of chinook in these terminal areas.

If these fisheries are not removed from the northern B.C. catch ceiling, significant disruption to existing fisheries and surplus escapements to some chinook stocks (particularly hatchery stocks) will likely occur. Catch of hatchery chinook could be facilitated by "add-on" requests for new production from hatcheries, but assessment of these increases will be costly and difficult to monitor. Therefore, it would be preferable to exclude these fisheries entirely from ceiling management.

Subcommittee Advice

Terminal exclusions for three areas are recommended but exclusions for the Nass River, and Rivers and Smith Inlets are not recommended at this time. The excluded areas and their catch during the base period would be (number of fish to be excluded from appropriate ceilings):

Skeena terminal area (2,400 fish);
Kitimat terminal areas (3,350 fish), and;
Bella Coola area (2,800 fish).

1.	203,000	for troll;
2.	34,800	for all nets (excluding the catch of under 5 lb. fish or "jacks"), and;
3.	16,650	for sport.
Total:	254,450	for all gear (before adjustments for over-ages).

Consequently, the catch in fisheries under the revised catch ceilings would be reduced but the total catch, in the area included under ceiling before these exclusions, should substantially exceed the previous 263,000 total catch ceiling. These exclusions would allow for increased incidental chinook catch during net fisheries, and harvest opportunities for chinook surplus to spawning needs and/or returns to enhancement facilities.

If terminal exclusions are to be requested for the three areas not recommended for exclusion in this document, then the Committee recommends that stock composition data be collected to support these requests.

4). Discussion Paper on Hatchery "Add-on" in Fisheries Limited by Catch Ceilings (Working Paper S88-25):

The Pacific Salmon Treaty imposed catch ceilings in several fisheries in British Columbia and S.E. Alaska. These ceilings were imposed to limit exploitation on chinook salmon and to limit interceptions of chinook and coho salmon. However, the Treaty does provide for each country to receive benefits from new production even in fisheries under catch ceilings. This provision particularly applies to increased production due to enhancement.

Increased production from enhancement may be used to assist rebuilding of natural chinook stocks by increasing the ocean abundance of chinook in fisheries under catch ceilings. As the abundance increases, the exploitation rate on all chinook stocks should decrease assuming that the same catch ceiling is maintained. This use of enhanced fish has been referred to as "buffering" natural stocks, but this does not provide any direct benefits to the country producing the increased numbers of enhanced fish. However, Article 2 in the Chinook Annex (Chapter 3, Annex 4) of the Salmon Treaty does allow for a country to choose to harvest the increased enhanced production following certain demonstrations. Specifically, the parties agreed:

> "that each region's catches will be allowed to increase above established ceilings based on demonstrations to the Commission and assessment by it of the specific contributions of each region's new enhancement activities, provided that the rebuilding schedule is not extended beyond 1998, and provisions of subsection 1(d)(vi) of this chapter are adhered to."

Specific allowances for increased catch of coho salmon are not explicit in the Treaty but increased hatchery production can be allowed for when renegotiating the west coast Vancouver Island catch ceiling. Catch ceilings for coho were only implemented in the west coast of Vancouver Island troll fishery.

Since 1985, Alaska has chosen to harvest their increased hatchery production of chinook salmon. This increased catch of hatchery fish has become known as their "add-on", since it is additional to the catch allowed under Treaty catch ceilings. The Alaskans were fortunate in that their enhancement programs began producing fish after the years used as base periods in establishing Treaty catch ceilings. Consequently, almost the entire hatchery production of chinooks in S.E. Alaska is considered to be new production. In Canada, however, major hatcheries were producing chinook during these base periods (generally 1977-84) but, since the early 1980's, catches of enhanced production have not been proportionate to increases in the numbers of chinook released. Consequently, the determination whether Canada has an "add-on" opportunity becomes less clear. Canada does, however, have several new facilities that are now contributing chinook and coho which were not produced during the base periods. Therefore, whether Canada requests an "add-on" depends on how new enhanced production is defined. This working paper examined the production of chinook and coho from all enhancement facilities and discussed opportunities for add-on in Canadian fisheries.

Enhancement Production of Chinook and Coho Salmon

A major review of production of these species was presented at the March, 1988 sub-committee meeting (Advisory Report S88-1). Releases of chinook and coho have increased substantially since the mid-1970s (Fig. 1a). Chinook releases have increased from 3 million in the 1974 brood year to 43 million in the 1985 brood year. Coho smolt releases increased from 2.4 million to 12.3 million for the same brood years, and releases of under-yearling coho have also increased dramatically. The resultant catch by Canadian fisheries (commercial and sport) has increased for coho salmon but has not been realized for chinook salmon (Fig. 1b). The latter situation probably reflects the recent general decline in the survival of chinook and alterations to the fisheries (changes in seasons open, reductions in fishing days, and catch ceilings).

Hatchery Add-on Calculations

Catch by hatchery and species were calculated using the coded-wire tag data for all enhanced production (major facilities plus smaller facilities and public involvement programs). Virtually all chinook production is associated with tagged groups but a significant proportion (up to approximately 25%) of the coho production is not directly associated. This unassociated production of coho was included by estimating its contributions by brood year and geographic area assuming enhancement bio-standards (i.e. expected rates of survival depending on the size at release). Contributions to specific fisheries were estimated by distributing the total contribution amongst fisheries based on the coded-wire tagged fish from the same brood year and geographic area. Enhancement contributions to northern B.C. sport fisheries were not included in these analyses. Very few coded-wire tags are, as yet, reported from this fishery. Less than 100 tags per year (between 1979-87) have actually been submitted to the Mark-Recovery Program.

The catches of B.C. hatchery chinook and coho by fishery and year are summarized in Table 2 (and by fishery, year, and hatchery in the appendix to Working Paper S88-25). What the potential "add-on" is, however, is a function of how an add-on is defined. Three options to define add-on were examined:

1) new production could be any production from facilities that started to contribute fish after a specified time;

2) new production could be production above the average total contribution of enhanced fish during a base period (this is the definition used by Alaska);

3) new production could be production above a base level of catch within each catch ceiling, the base level being established as the proportion of the ceiling that enhanced fish contributed to the total catch during a base period.

In each of these options some time period must be selected to compare present production to; for example a base period might be the 1979-82 base period used to establish the chinook rebuilding program (the 1979-82 period was used to define old vs. new enhancement facilities in Table 2) or might simply be 1984 which was the year immediately prior to the signing of the Treaty. The only technical guidelines for selecting an option and time period seems to be that an add-on can not be allowed if it would deter from chinook rebuilding.

In option 1, an "add-on" would be requested for the catch from new facilities without consideration of the production from older facilities. For example, in northern B.C. fisheries new facilities are contributing catch but the total catch of all enhanced chinook is presently less than during the 1979-82 period (Fig. 2a). Conversely, in the west coast of Vancouver Island troll fishery, the combined catch of coho from new and old facilities exceeds the catch during the 1979-82 period (Fig. 2b). Canada could argue that by claiming the new enhanced catch as an "add-on", that the fishery impact remains the same as it would have been without the new enhancement. This is true, however, only in the situations where the number of harvestable chinook produced from the older facilities has not dropped from the base period, and contributed to a slowing of rebuilding. Claiming new enhancement as an "add-on" during the latter situation would slow rebuilding further and would be undesirable.

An additional consideration is that by persuing this option, we may forego the potential for claiming a large "add-on" when the old production rebounds to higher catch contribution rates. Further, there is the difficulty in defining whether new or altered production and/or methods in old facilities constitute new production.

In option 2, the present catch of enhanced fish would have to be greater than base period levels to claim an "add-on". Unfortunately, recent trends in catches of Canadian hatchery chinook indicate that an "add-on" for chinook would not currently be justified. However, an add-on for coho salmon in the west coast troll fishery may be available. If an add-on for chinook is to be based on this option then we will have to wait until survivals of hatchery chinook return to the higher levels observed in the mid-1970s.

Option 3 may seem to be the most practical means to determine the size of an add-on since the catch ceilings are substantially lower than the average catches in years previous to the Treaty. Consequently, if the absolute catch of enhanced fish during periods when catch ceilings were not imposed was used as the minimum level enhanced fish must contribute before an add-on is allowed, then we may not ever receive an add-on because the ceilings limit our access to increased enhanced production.

However, option 3 assumes that the background stock composition of the fisheries has not changed. This information would be necessary to evaluate whether the add-on would influence rebuilding. Consequently, this option may be difficult to evaluate and convince the Commission that an add-on would not have an impact on the rebuilding program.

Subcommittee Advice

At this time, the only positions on "add-on's" which are supported technically seem to be to harvest increased chinook returns in terminal areas of northern B.C. and coho in the west coast of Vancouver Island troll fishery. Options for chinook "add-on" in outside troll fisheries under catch ceilings cannot be technically justified since the previous production of hatchery chinook exceeded recent catches of chinook from Canadian enhancement facilities, both on an absolute catch and as a percentage of the total catch (there has been essentially no change in the proportion of the total west coast Vancouver Island troll chinook catch contributed by Canadian enhancement). Further, it is not certain that coho add-on's are permissible under the Treaty; the committee recommends that this option be investigated during this year's negotiations.

Before Canada requests any "add-on" we must determine what risk adjustment calculation to use. Risk adjustment was introduced in the Alaskan add-on procedure and basically protects against over-estimating the add-on and subsequently fishing more of the other stocks in the fishery. The subcommittee supports the determination of a risk adjustment factor but also recommends that we not accept the American procedure without evaluating alternatives. This consideration is presently being investigated. Furthermore, if add-on's are requested for terminal areas in northern B.C. it is likely that specific sampling programs for coded-wire tags in these small areas will be required. Normally, sampling data for the coded-wire tag program is conducted over larger geographic areas.

Table 1. Summary of the potential for chinook catch exclusion in northern B.C. fishing areas. This list includes all current and potential fisheries for consideration of exclusion from the current catch ceilings for chinook.

Area	Fishery	Evaluation
1	Outside "interception".	Mixed stock, not appropriate for exclusion. No future prospects.
1	Masset Inlet.	No current prospects. Long term terminal fishery potential, if Yakoun R. surplus available.
2E & 2W	Cumshewa chinook. Experimental transplant from south.	Currently no chinook net or sport catch in Cumshewa Inlet. All future catches in Cumshewa Inlet that will result from this hatchery stock should be excluded.
2E & 2W	All areas, except Cumshewa Inlet	No local stocks, not appropriate for exclusion.
3	Subarea 3(1-4) or 3(X+Y)	Mixed stock, not appropriate. No future prospects.
3	Subarea 3(7-17) or 3(2)	Nass stocks assumed to be abundant in 3-12 (subarea adjacent to Nass R. mouth) during June-July period.
4	Outside areas (outer portions of 4-12 and areas seaward).	Mixed stock areas - Skeena stock would form large component of June-July catches. No technical assessment feasible at this time.
4	River fishery (4-15 and inner portion of 4-12).	Assume all Skeena stocks. Catch from this area should be excluded.
5	All areas.	Mixed stock, not appropriate for exclusion. No future prospects.
6	Current fishing areas (Gil Is.).	Mixed stock, not appropriate for exclusion.
6	Kitimat terminal areas.	Current discrete terminal area fishery (sport). Major hatchery and natural production expected in future years. Prospects for future terminal net fisheries. Catch in this area should be excluded.
7	All areas.	Mixed stock, not appropriate for exclusion. No future prospects.

Table 1 (cont'd).

Area	Fishery	Evaluation
8	Dean Channel.	Current fisheries occur after local chinook stocks have migrated through. Long term future prospects for target chinook net fishery if Dean chinook surplus available.
8	Bella Coola Gillnet.	Current terminal fishery on Bella Coola chinook only. Should be excluded. Large potential surplus of natural and hatchery stocks in future years.
9	Current fishing areas "Terminal".	Mixed stock, chinook >20 lbs. may largely be of Rivers Inlet origin. Size data currently only available for sport caught chinook.
10	Current fishing areas "Terminal".	Mixed stock, not appropriate for exclusion. Possible future separation by size (no data at this time).

Table 2. Estimated contributions of chinook and coho salmon, produced in Canadian enhancement facilities, to Canadian fisheries with catch ceilings established by the Pacific Salmon Treaty. Catches of enhanced fish are indicated by facilities which contributed catch in the base period (1979-82) and previously (OLD), and facilities which have begun to contribute fish since this period (NEW). Virtual all chinook productions can be accounted for by associating it with a coded-wire tagged group of chinook. However, for coho salmon an increasing number of fish can not be readily associated with a tag group, this production is referred to as UNASSOC.

Catch			Catch Year									
Region	Gear	Species	1979	1980	1981	1982	1983	1984	1985	1986	1987	Avg. 1979-1982
Northern B.C.	Troll	Chinook										
OLD			26170	29290	26700	35490	33820	23390	18140	12980	9010	29413
NEW			160	290	250	1090	2680	5800	3830	3720	6500	448
TOTAL			26330	29580	26950	36580	36500	29190	21970	16700	15510	29860
Northern B.C.	Net	Chinook										
OLD			12070	11190	8240	13060	9160	8110	9450	10380	6400	11140
NEW			70	230	230	710	560	510	1500	6670	2360	310
TOTAL			12140	11420	8470	13770	9720	8620	10950	17050	8760	11450
Northern B.C.	Troll+	Chinook										
OLD	Net		38240	40480	34940	48550	42980	31500	27590	23360	15410	40553
NEW			230	520	480	1800	3240	6310	5330	10390	8860	758
TOTAL			38470	41000	35420	50350	46220	37810	32920	33750	24270	41310
West Cst. Van. Is.	Troll	Chinook										
OLD			7300	15160	5760	10010	7600	10600	2800	2940	2570	9558
NEW			0	0	0	80	120	7700	7560	6520	6020	20
TOTAL			7300	15160	5760	10090	7720	18300	10360	9460	8590	9578
West Cst. Van. Is.	Troll	Coho										
OLD			40210	41750	41790	48770	64830	86740	37100	65770	46600	43130
NEW			0	90	480	410	3950	11590	20990	75840	98980	245
UNASSOC.			960	7860	1260	8090	4550	14040	36090	34620	35355*	4543
TOTAL			41170	49700	43530	57270	73330	112370	94180	176230	180935	47918

* The 1987 estimate for unassociated coho is not available yet, and was simply estimated as the average of 1985 and 1986.

Fig. 1a. Canadian hatchery releases of chinook and coho salmon.

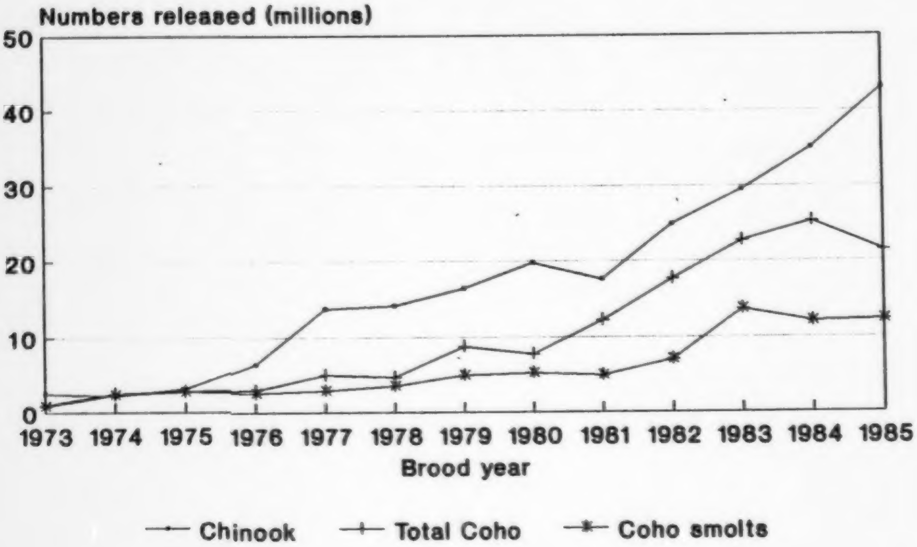


Fig. 1b. Catches of Canadian enhanced chinook and coho salmon.

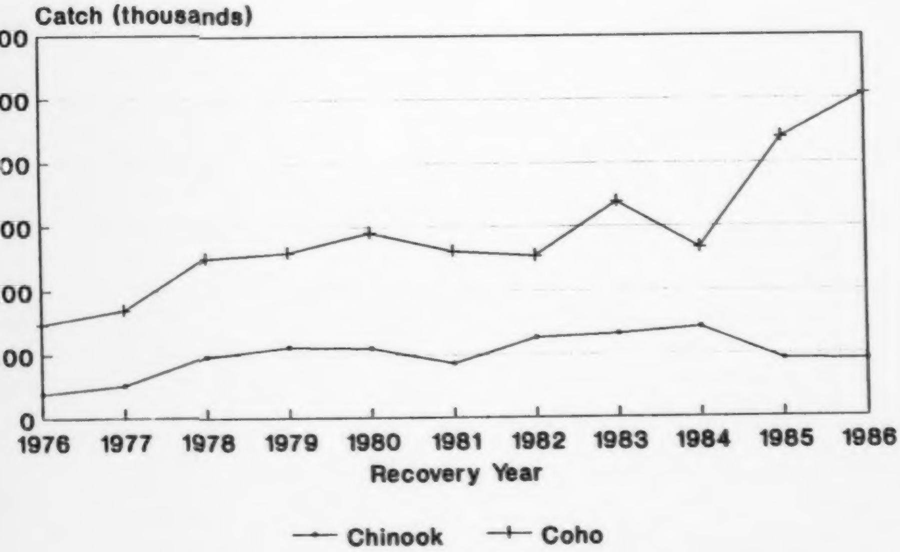


Fig. 2a. Contributions of enhancement to Northern B.C. commercial fisheries.

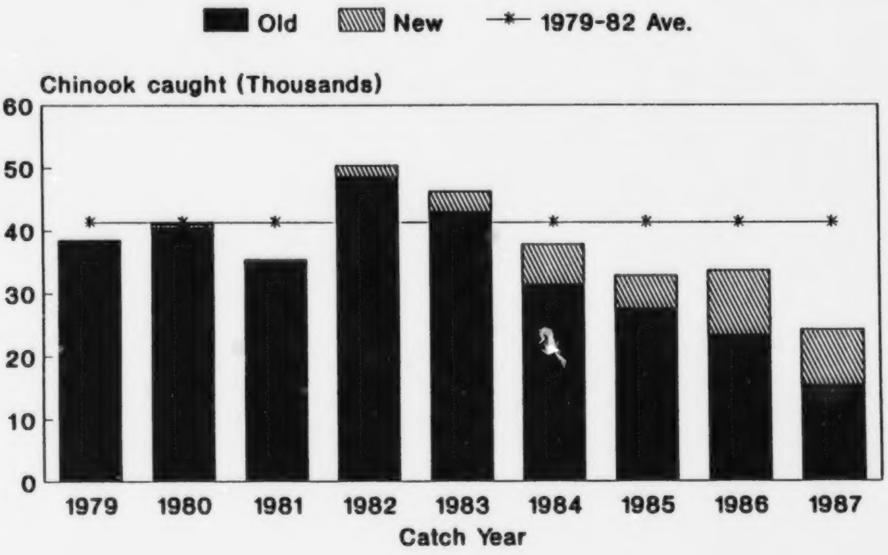
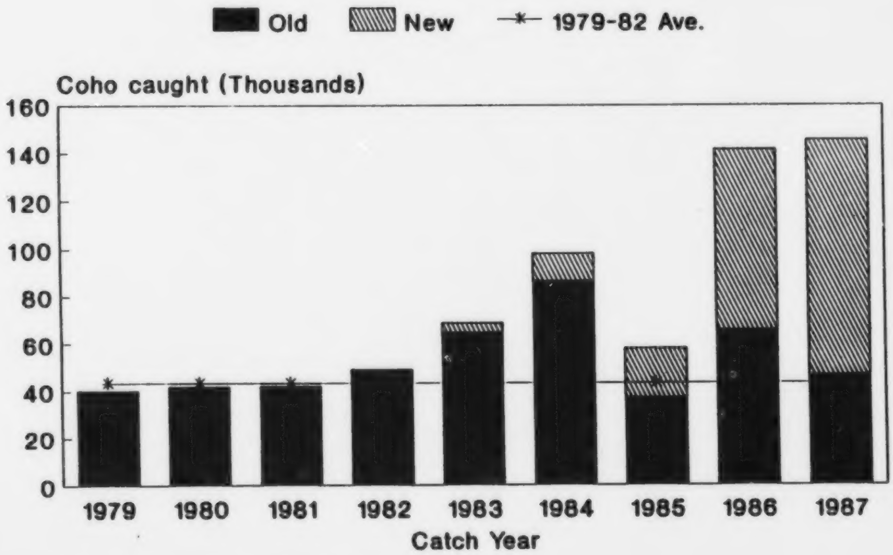


Fig. 2b. Contributions of enhancement to the west coast Van.Is. troll fishery



Unassociated production excluded.